Digital Decision-Making:
Using Computational Argumentation to Support Democratic Processes

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This thesis is dedicated to my grandmother, Evelyn, and the memory of my grandfather, Guido. I could not have wished for two finer role models.

Abstract

One of the key questions facing governments around the world is that of how to increase and maintain the engagement of citizens in democratic processes. Recent thought, both within academia and government itself, has turned to the use of modern computational technology to provide citizens with access to democratic processes. Access to computer and Internet technology by the general public has vastly increased over the past decade, and this wide access is one of a number of motivations behind research into the provision of democratic tasks and processes online.

The particular democratic process that forms the focus of this thesis is that of online opinion gathering in order to aid government decision making. The provision of mechanisms to gather and analyse public opinion is important to any government which claims to promote a fair and equal democracy, as decisions should be made in consideration of the views and opinions of the citizens of such a democracy. The work that comprises this thesis is motivated by existing research into harvesting opinion through a variety of online methods. The software tools available largely fall into one of two categories: Those which are not based on formal structure, and those which are based on an underlying formal model of argument.

The work presented in this thesis aims to overcome the shortfalls inherent to both of these categories of tool in order to realise a software suite to support both the process of opinion gathering, and analysis of the resulting data. This is achieved through the implementation of computational models of argument from the research area of argumentation, with special consideration as to how these models can be used in implemented systems in a manner that allows laypersons to interact with them effectively.

A particular model of argument which supports the process of practical reasoning is implemented in a web-based computer system, thus allowing for the collection of structured arguments which are later analysed according to formal models of argument visualisation and evaluation. The theories underlying the system are extended in order to allow for added expressivity, thus providing a mechanism for more life-like argument within a system which supports comprehensive computational analysis.

Ultimately, the contributions of this thesis are a functional system to support an important part of the democratic process, and an investigation into how the underlying theories can be built upon and extended in order to promote expressive argumentation.

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Chapter 1

Introduction

1.1 Overview

In this section I introduce my research question, before describing the topics on which my research is based. I then give an outline of the structure of this thesis.

1.2 Research Question

Decision-making is a process that is central to any government. The question "What should we do?" is one that arises whenever a government must act to address a policy issue in order to resolve an undesirable situation, or to achieve an advantageous state of affairs. A truly democratic decision can only be made through democratic deliberation, in which every citizen is given the opportunity to express his or her opinion on the matter. Traditionally, providing opportunities for the entire electorate to participate in such opinion gathering tasks has not been easy.

e-Democracy is a term coined in the 1990s to describe the utilisation of electronic communication technologies in order to enhance democratic processes. Such communication technologies could include channels such as telephones, television, and radio, but the term is mainly used to describe communications that take place over the Internet. e-Democracy provides governments with increased opportunities to access the large majority of their citizens for purposes including consultation over governmental decisions. However, if governments are to successfully harness the large and expanding availability of the Internet in order to gather public opinion on issues surrounding government policy, then effective methods of gathering and analysing these opinions must be developed.

Computational argumentation, a research area in which philosophical ideas from argumentation theory are applied within AI, provides computational methods which allow us to structure, visualise, and ultimately evaluate arguments and the various positions that can be constructed from such arguments. The aim of this thesis is to bridge the research areas of Argumentation and e-Democracy in order to answer the following question:

> *How can democratic decision making be supported and enhanced by technologies that make use of computational models of argument?*

This question arises from the large body of literature that exists in both research areas, with little work considering how the two could be merged in order to develop systems which can harness the power of computational arguments in order to support decision making, yet appreciate the challenges of developing tools for use in e-Democracy applications. The need for such a system is exemplified by a statement made by a candidate of the American presidential election in 1992; Ross Perot stated:

> "I would create an electronic town hall where, say, every week or so we would take a single major issue to the people. We would explain it in great detail and then we would get a response from the owners of the country - the people - that could be analyzed by congressional district so that the Congress - no if's, and's and but's - would know what the people want"

Here Perot describes the need for an interactive method of determining exactly what the public think, feel, and desire on particular topics of interest. In this thesis, I will investigate the research question set out in this chapter through the development of a set of software tools and the supporting theories of argumentation that underpin these tools.

1.3 Overview of Research Areas

As discussed in the previous section, the work presented in this thesis makes use of literature from two existing research areas; e-Democracy (and other related fields, including e-Participation and e-Government) and Argumentation Theory.

e-Democracy focuses on the use of computing technologies in enhancing democratic processes. It is defined by Macintosh [95] as "capturing both the intent to support democracy and study the outcomes and context". Earlier work by Macintosh [92] defines e-Democracy as "concerned with the use of information and communication technologies to engage citizens, support the democratic decision-making processes and strengthen representative democracy". In their 2001 book, Hacker and Van Dijk define "digital democracy" as "a collection of attempts to practice democracy without the limits of time, space and other physical conditions, using ICT [...], as an addition, not a replacement for traditional 'analogue' political practices" [63].

The emergence of e-Democracy is a result of ubiquitous access to computing and Internet technologies, as well as the time and expense that can be saved by government processes being made available over the Internet rather than in their traditional format. e-Democracy encompasses a number of different democratic processes, all of which enable a government and its citizens to communicate and exchange ideas, information, and opinions. Examples of such processes include electronic voting (for example, government elections), provision of information using online mediums, and the gathering of public opinion.

Johnson [71] defines e-Democracy as "the use of the Internet as a medium for democratically selecting political leaders, public policies, or both". Johnson's definition of e-Democracy touches on the use of the Internet to democratically select public policies, and it is on this particular topic that the research presented in this thesis is concentrated.

Numerous accounts of the levels of participation available in online democratic processes are present in the literature. Some of the different accounts are considered by Fraser *et al.* [53], and are then summarised as:

- e-Informing: A one-way channel, in which the government provides information to citizens (e.g. official websites) or citizens provide information to the government (e.g. e-Petitions).
- e-Consulting: A limited two-way channel, where stakeholders can contribute their opinion, either privately or publically, on specific issues.
- e-Collaborating: An enhanced two-way channel, which acknowledges the active role of all stakeholders in proposing and shaping policy. The responsibility for the final decision rests with officials.
- e-Empowering: Refers to the placement of the final decision in the hands of the public (e.g. referenda).

As identified by the research question presented in the previous section, the main focus of this thesis is on decision making in e-Democracy. Decision making can be thought of as a method of determining the best course of action to take in a given set of circumstances, perhaps in order to achieve some particular goal. This type of reasoning is known within the field of philosophy as *practical reasoning*, a topic which has been a focus of philosophical research since the time of ancient Greek Philosophers. There are a number of differing accounts of how to construct and represent practical reasoning problems, and I discuss the roots of practical reasoning further in Chapter 4.

An important part of practical reasoning is the process of evaluating different criteria in order to determine the best course of action. A selection of competing actions may need to be considered in order to determine which is the most appropriate. In order to help with this process, we can turn to *argumentation theory*, another sub-field of Philosophy. Argumentation theory concentrates on structuring, presenting, and evaluating arguments that support or reject a particular stance on a topic of debate. In the context of e-Democracy applications, argumentation theory provides us with useful methods of evaluating different perspectives and points of view on a particular topic of debate, in order to reach a democratic consensus. *Argumentation schemes* are a particular method of presenting and criticising arguments, and are of particular importance to this thesis; these schemes allow for positions of argument to be structured in natural language, and critically questioned in order to raise potential objections.

Some research already exists into how computational tools can be used in order to gather opinions from the public in a manner which allows the government to analyse the data and, ultimately, make decisions. Some of the most relevant literature in this area is presented and discussed in Chapter 2. The main tools that exist in the literature either allow free, unstructured, argument or are based on formal structures of argument taken from the research field of Argumentation Theory.

This clear categorisation of tools creates an issue that underpins the work developed in this thesis: tools that allow for unstructured argument encourage interaction by being easy to use, and often allow respondents to be highly expressive in their responses. However, difficulties are encountered when one tries to computationally analyse the data collected using such systems. In an attempt to overcome this problem, recent research has concentrated on implementing computational models of argument in opinion gathering tools to allow more effective, and better quality, analysis to take place. However, understanding and interacting with these formal argument structures often proves challenging to laypersons, thus potentially reducing the level of participation achieved using such tools.

The work presented in the rest of this thesis concentrates on the development of a particular tool for use in the collection and evaluation of public opinion on a selected topic of debate, in order to aid democratic decision making. The development of such a tool will be based on formal models of argument, in order to allow the data collected to be analysed and evaluated computationally. As the tool is to be used to collect opinion from laypersons, it must remain easy to use and avoid confusing the users with formal structures which they may find difficult to understand and interact with. After presenting the software I have developed, I consider how it can be expanded and formalised to extend its capabilities beyond the representation of simple arguments.

Having identified and described the main research areas under which my work falls, I now articulate the contributions of this thesis:

1. The development of a software tool for democratic opinion gathering, that is based on formalisms taken from the research area of argumentation theory in order to provide computational analysis and evaluation of the data collected. The

software should provide respondents and governments with the ability to be as expressive as possible in their interaction with the system, in order to provide a superior alternative to existing methods of consultation.

2. Consideration of how the structured representation of different arguments can interact, to support and challenge each other. I develop computational models of argument interaction in order to allow for increased expressivity in structured argumentation.

3. The illustration of how the structures of argument used within my software tool can be formalised for use in automated agent systems; and investigation of how this could be of use both within the tool that I develop, as well as other domains.

In Chapter 10, I will return to consider the research aims set out in this chapter and determine whether they have been fulfilled by the work presented in my thesis. I now turn to consider the structure of the proceeding chapters.

1.4 Thesis Structure

This thesis consists of ten chapters, in addition to a set of accompanying appendices. The structure is as follows:

Chapter 1 is this chapter, in which I introduce my research question and discuss the research areas on which my thesis is based.

Chapter 2 presents a survey of existing literature relevant to the contribution made by this thesis.

Chapter 3 considers opinion gathering in democracies, from its traditional roots to the modern computational methods used by governments to solicit opinions from citizens. Two types of computational tools are identified: Those which are based on formal computational models of argument and those which allow for "free" informal argument. The investigation in this chapter pinpoints some of the issues present in each of these categories of tool, in order to motivate the research described in the rest of the thesis.

Chapter 4 discusses the roots of practical reasoning, considers its application to AI, and investigates how argumentation schemes can support the process of practical reasoning in e-Democracy.

Chapter 5 introduces the Parmenides system, a software tool I have developed to support decision making over government plans for action in e-Democracy. Parmenides is developed to overcome some of the issues facing tools for e-Democracy that were described in Chapter 3. The aim of Parmenides is to provide a structure which allows for data to be collected and analysed effectively, yet remains easy for laypersons to interact with.

Chapter 6 considers the theories of argumentation underlying the Parmenides system, investigating how argumentation schemes can be used to attack and support other schemes through critical questioning. The discussion is supplemented with a range of example interactions between schemes, which I subsequently generalise.

Chapter 7 presents a considerable expansion of the Parmenides toolset, based on the findings of Chapter 6. The extensions enable Parmenides to represent multiple interacting arguments, allowing governments to provide persuasive evidence to support the claims put forward in their arguments, which can then be critiqued by respondents.

Chapter 8 provides some insight into how the argumentation schemes on which the Parmenides system is based could be formalised, in order to develop systems for automated computational reasoning. The chapter explores an existing approach to formalising the argumentation scheme for practical reasoning, before illustrating this approach with a debate previously implemented in the Parmenides system.

Chapter 9 presents two preliminary evaluations which have been carried out on the Parmenides system. The results of the evaluations are critically analysed in order to give an insight into whether Parmenides has achieved its aims, and future improvements to the system are also discussed.

Chapter 10 concludes with a summary of the contributions made by this thesis and a discussion of possible future research directions.

There are also three appendices to the thesis: **Appendix A** is a full account of the results of the evaluations carried out on the Parmenides System, which are analysed in Chapter 9. **Appendix B** contains design documentation for the Parmenides software tools, including the Parmenides website through which public opinion is solicited, and the Java analysis tool which analyses the results. **Appendix C** contains the full definitions of a number of the argumentation schemes which are referred to extensively throughout the thesis, and their associated critical questions.

Some of the work presented in this thesis is based on work which I have had published in journals and presented at refereed conferences. The following segments of the thesis are based on work which was co-authored and published with my supervisors, Dr. Katie Atkinson and Professor Trevor Bench-Capon:

- The development of the Parmenides system and the associated analysis tools were published in [31]: D. Cartwright and K. Atkinson. Political engagement through tools for argumentation. In *Proceedings of the Second International Conference on Computational Models of Argument (COMMA 2008)*, pages 116-127, 2008.

- Some examples of the use of Parmenides are described in [164]: D. Walton, K. Atkinson, T. Bench-Capon, A. Wyner, and D. Cartwright. Argumentation in the framework of deliberation dialogue. In C. Bjola and M. Kornprobst, editors, *Arguing Global Governance*, pages 210-230. Routledge, 2010.

- Extensions to the Parmenides System, which encompass the use of different argumentation schemes, were published in [33]: D. Cartwright, K. Atkinson, and T. Bench-Capon. Supporting argument in e-Democracy. In *Proceedings of the Third Conference on Electronic Democracy (EDEM 2009)*, pages 151-160, 2009.

- The Parmenides System and its contribution to electronic democracy are described in [32]: D. Cartwright and K. Atkinson. Using computational argumentation to support e-Participation. *IEEE Intelligent Systems*, 24:42-52, 2009.

Chapter 2

Literature Review

In this chapter, I present a review of the literature that is relevant to the research described in this thesis. I begin in Section 2.1 by describing Argumentation Theory in philosophy; a research area which has its modern roots in the work of authors such as Toulmin and Perelman from the mid-20th century, although the topic itself dates back to ancient Greek philosophers such as Aristotle. I then describe some of the recent research which has applied argumentation theory within the discipline of Artificial Intelligence.

In Section 2.2 I consider software tools developed to support the process of argumentation within computational systems. I discuss the theoretical groundings of such systems before turning to examine the range of software systems available and describing the most relevant systems in detail. Many of the systems available to support computational argument are built upon the theories of Argumentation within Artificial Intelligence described in Section 2.1.

I conclude the literature review with a brief review of research within the emerging area of e-Democracy. This review is extended in Chapter 3, where I consider some of the literature relevant to the particular strand of e-Democracy on which this thesis is based.

2.1 Argumentation Theory

A number of differing definitions have been attributed to the notion of an *argument* in the argumentation theory literature. These definitions vary based on the domain in which the research is based and the particular application of argument that is being considered. Rahwan and Simari provide a definition in [129] that is both general and concise: "An argument is a set of statements (propositions) made up of three parts, a conclusion, a set of premises, and an inference from the premises to the conclusion".

The theory of argumentation is a research area which straddles a number of different disciplines, including Artificial Intelligence, philosophy, linguistics and psychology. Argumentation is defined by Van Eemeren *et al.* in [49] as "a verbal and social activity of reason aimed at increasing (or decreasing) the acceptability of a controversial standpoint for the listener or reader, by putting forward a constellation of propositions intended to justify (or refute) the standpoint before a rational judge". Moraitis and Spanoudakis define it as "the principled interaction of different, potentially conflicting arguments to obtain a consistent conclusion" [108]. Based on these definitions, one can see the relevance of argumentation theory to the research question posed in Chapter 1, in which democratic decisions (consistent conclusions) are to be deliberated over, in the face of numerous different opinions.

Macintosh *et al.* note that "the goal of argumentation is to determine the acceptability of claims, rather than their truth" [93]. The same authors also note that, in contrast to logical consequences, arguments are "defeasible" because their consequences are only plausible and not certain, and can be defeated by providing a counter argument or by revealing premises of the argument to be untrue or impossible. Argumentation theory aids not only the building of arguments, but also the analysis of them in order to determine their acceptability.

In this section, I examine the theories of argumentation that are relevant to this thesis. I begin by discussing the structure of arguments, before considering computational models of argument representation and reasoning which allow us to embody and evaluate such arguments.

2.1.1 Structuring Argument

In this section, I consider some of the existing literature on the topic of structuring arguments. The work presented here typically attempts to decompose arguments into their constituent parts, in order to allow them to be structured and reasoned with effectively.

2.1.1.1 Toulmin's Theory

Toulmin's Schema of argument [150] is a precursor to the modern understanding of argumentation schemes that is described in Section 2.1.1.2. By breaking arguments down into a number of separate constituent components, the schema allows for more expressivity than previous schemes for argument which were based on upon logical proofs consisting of a set of premises and a conclusion.

A Toulmin Schema contains three major components, which are necessary, and three further optional components which can be specified by the proponent of the argument if desired. Each of the potential six constituent components describes the different roles that each particular premise can play in the structure and analysis of an argument. The three major components of the schema are the *claim*, the *support*, and the *warrant*:

- **Claim**: The conclusion of the argument; the point that the author of the argument is trying to prove
- **Data**: A traditional premise of the argument; a fact or observation given by the author of the argument in order to justify the claim
- **Warrant**: Licenses the derivation of the claim from the data

The additional elements, which can be used by the proponent as the need arises, are the *qualifier*, *rebuttal*, and *backing*:

- **Qualifier**: States the strength (degree of certainty) of the argument for the claim
- **Rebuttal**: A proposition which would refute the claim, if the claim was proved true; allows the taking into consideration of conflicting viewpoints
- **Backing**: Provides support for the warrant, to further "back up" the argument

The relationship between all of these argument elements is depicted in Figure 2.1.

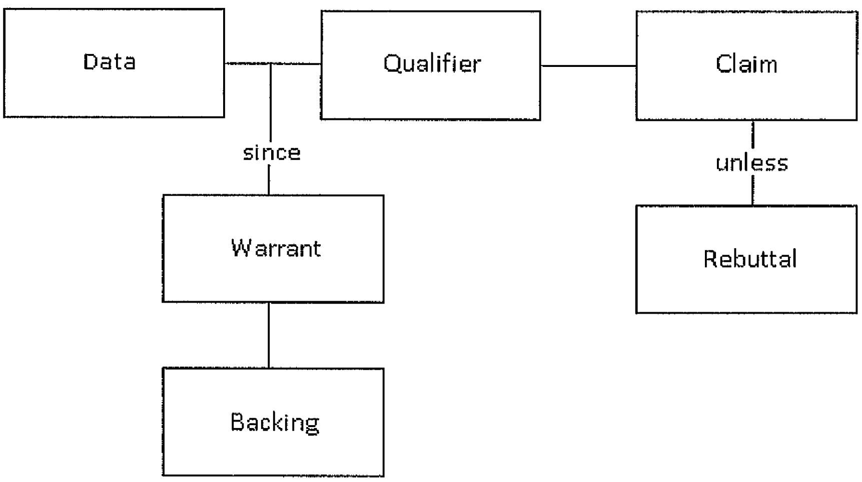


Figure 2.1: Toulmin's Argument Schema

Toulmin's scheme has proved to be a popular method of providing a well structured and clear form of argument representation, and has formed the basis of a number of implemented systems (e.g. [23], [97], [173]) including a dialogue game [19] in which the moves available correspond to supplying one of the elements of Toulmin's schema.

In [150], Toulmin gives an example application of his schema in the form of an argument about whether a particular person is classed as a British citizen. In this example, the elements of the scheme are instantiated as follows:

- **Claim**: "I am a British citizen"
- **Data**: "I was born in Bermuda"
- **Warrant**: "A man born in Bermuda will legally be a British Citizen"
- **Qualifier**: To express a higher degree of certainty over the claim, the speaker could claim "I am definitely a British citizen".
- **Rebuttal**: Recognising exceptions to the rule, this could be instantiated as "A man born in Bermuda will legally be a British citizen, unless he has betrayed Britain and has become a spy of another country"
- **Backing**: if the listener does not deem the *Warrant* as credible, the speaker could supply the legal provisions as a backing statement to show that it is true that "A man born in Bermuda will legally be a British Citizen"

This example from [150] exemplifies the use of his schema in representing the reasoning behind an argument that could put forward in an everyday conversation. Although Toulmin's schema is undoubtedly a significant contribution to argumentation theory, one shortfall with the model is that it lacks any method of precisely identifying the source of conflict within an argument. Unlike the critical questions developed as part of later work on argumentation schemes by Walton (described in Section 2.1.1.2), Toulmin's model provides very little in the way of a precise definition of how arguments can be attacked. Although the schema does allow for challenges to the argument in the form of a rebuttal, it does not explicitly represent the manner of the attack that is taking place. For example, no mechanism exists to distinguish between attacks that are *rebuttals* (arguments which negate the conclusion - or the *claim* - of the original argument) and those that pose an *undercutter* attack (arguments which attack the inference between the premises of an argument and the conclusion, and so relate to the warrant rather than the claim). These two different types of attacking argument were first identified by Pollock in [123], and allow us to identify more precisely the type of attack that is being posed against an argument which consists of a set of premises and a conclusion. The fact that Toulmin's model does not allow for distinction between these two types of attack means that it may not always be easy to identify the precise nature of any disagreement.

2.1.1.2 Walton's Argumentation Schemes

The work of Toulmin, described in the previous section, was to create one particular schema that could be applied to any argument by instantiating the different elements with specific data. Here, I describe the work of Walton, who has developed a wide range of argumentation schemes to cater for the different types of argument that exist in real life debate.

Walton's argumentation schemes allow the representation of stereotypical patterns of reasoning, in order to provide a presumptive justification for believing that the argument represented by the scheme is true. Arguments represented using these schemes can be challenged by posing one of the *critical questions* associated with the particular scheme. As each of Walton's schemes consists of different premises and conclusions, then the critical questions also must differ in number and formulation from scheme to scheme. Typically, at least one critical question exists to challenge each of the presumptive elements of the scheme.

In his 1996 book, Walton identifies 26 different schemes which cover a variety of argument types [162]. The proponent of an argument must select the scheme which matches the type of argument that he wishes to represent, and instantiate the elements of the scheme with the details particular to his argument.

The schemes identified by Walton in [162] include those for arguing based on the statement of an expert, those for representing causal and consequential arguments (e.g. state of affairs A will cause state of affairs B), and arguments based on precedents. By way of an example, the following is one of the argumentation schemes introduced by Walton, and is named "Argument from Expert Opinion":

> ***E* is an expert in domain *D*. *E* asserts that *A* is known to be true. *A* is within *D*. Therefore, *A* may (plausibly) be taken to be true.** [162]

By instantiating the elements emphasised in the above statement of the scheme (Expert E, Domain D, and Fact A), a presumptive argument exists in favour of A being true. The other schemes in Walton's book follow a similar structure, embodying a set of premises and a conclusion, with certain presumptive elements which must be instantiated by the user of the schemes. The following are the critical questions for the "Argument from Expert Opinion scheme" stated above:

CQ1: Is E a genuine expert in D?
CQ2: Did E really assert A?
CQ3: Is A relevant to domain D?
CQ4: Is A consistent with what other experts in domain D say?
CQ5: Is A consistent with known evidence in domain D?

One can see that this range of questions provides opportunity for a respondent to critique any presumption put forward by the proponent of an argument instantiated using this scheme, thus provoking consideration of alternatives that should be considered, and consequently promoting the best choice of argument in the context of the current situation. An argument within one of Walton's schemes can be considered *defeasible*, as it requires that satisfactory answers be given to any critical question posed in order for the argument to withstand critique.

In [158], Verheij proposes a classification of critical questions based upon the way in which they attack the argument instantiated using the particular scheme. The categories (termed as the "roles" of critical questions by Verheij) are as follows:

- Those which challenge the premises of the argumentation scheme
- Those which point to exceptional situations in which the scheme should not be used
- Those which correspond to "conditions for a scheme's use" - i.e. conditions that should hold for the argument to be valid
- Those which point to other arguments relevant for a scheme's conclusion - i.e. those which are *for* or *against* the conclusion

From the above classification of critical questions, one can see that there are a wide range of different types of critical questions that can be posed against arguments instantiated using Walton's argumentation schemes. This is in contrast to Toulmin's schema, one of the main criticisms of which is that the only type of attack which can be posed against the schema is in the form of a rebuttal attack on the conclusion of the argument.

In Walton's 2008 book [166], he expands the 26 schemes in his previous book to a total of 60 different argumentation schemes, of which some of the new schemes are variations of the existing ones. In addition to the introduction of additional schemes, [166] also discusses a classification of argumentation schemes, with the conclusion that "given that the schemes have not yet been formalized, and therefore have not yet been precisely defined in a formalistic way, any classification system will eventually have to be modified". In Chapter 6, I consider how the critical questions of a range of argumentation schemes can be responded to using other schemes. If a classification of schemes were to be developed, then this could aid in defining broad definitions of how argumentation schemes of different classifications can interact.

The popularity of Walton's argumentation schemes can be seen in their large and varied use throughout the literature. Their use in the legal domain is demonstrated by Verheij in [158], where he develops a model showing how Walton's notion of schemes can be embedded in a formal model of dialectical argumentation for use in legal reasoning. In [171], Wyner and Bench-Capon consider the reconstruction of Legal Case-Based Reasoning (LCBR) in AI and Law in terms of argumentation schemes, comparing and contrasting this approach with three other systems which implement LCBR. Bench-Capon *et al.* demonstrate in [21] how argumentation schemes for practical reasoning can be used to aid the representation and evaluation of legal arguments in terms of Value-based Argumentation Frameworks, a method of argument evaluation that I discuss further in Section 2.1.2.2. A further example of the application of argumentation schemes to the legal domain is [124], in which they are used to reason about evidence.

In addition to the work described above, there have been a number of implemented software tools which use argumentation schemes in order to structure and/or reason over the positions within the system. The *Araucaria* tool of Reed and Rowe [144] is designed to support students and human analysts in the marking up of arguments, and uses the Argument Markup Language (AML) to describe the structure of arguments. *Compendium* [42] is a software tool for mapping discussion, which can call upon argumentation schemes to represent positions and claims. *Rationale*[1] is another tool for argument mapping and visualisation, which supports abstract models of argumentation schemes which the user must instantiate with the necessary details. I conduct a comprehensive survey of argumentation support tools in Section 2.2.

This concludes my review of argumentation schemes in the literature, however I return to consider argumentation schemes for practical reasoning in Chapter 4, where I consider a specific scheme that is a key component of the work described in this thesis. Next I discuss the work of Walton and Krabbe in identifying the different types of dialogue in which arguments themselves can be embedded.

2.1.1.3 Dialogue Typology

In [165], Walton and Krabbe define a typology over dialogues that appear within human communication. Walton later defines a *dialogue* as a "normative framework in which there is an exchange of arguments between two speech partners reasoning together in turn-taking sequence aimed at a collective goal" [163]. In addition to dialogue between humans, more recent research has concentrated on how the dialogue typology of Walton and Krabbe applies to communication between computational agents (McBurney and Parsons provide an overview in [102]). Often, dialogues within such systems share the same purpose and goal as dialogues that occur between human participants.

The dialogue types identified by Walton and Krabbe are *Persuasion*, *Inquiry*, *Negotiation*, *Information-seeking*, *Deliberation* and *Eristic*. The categorisation of a dialogue depends on a three factors; the relevant information available to the participants at the start of the dialogue, the goal of each individual participant, and the goals shared by all of the participants. The dialogue types can be summarised as follows:

- **Information-seeking:** One participant does not know the answer to a particular question, and tries to seek the answer from another participant who is believed to know the answer. An interview is one example of a scenario in which an information-seeking dialogue may be used.

[1] http://www.austhink.com/

- **Inquiry:** All participants do not know the answer to a question or set of questions, and collaborate in order to obtain an answer and broaden their knowledge.
- **Persuasion:** In a situation in which conflicting points of view exist, one participant seeks to convince another to accept a proposition that he currently does not believe to be true. The proposition could be a belief or a proposal for action.
- **Negotiation:** Participants bargain over the division of a scarce resource. The goal of the dialogue is to obtain a division of the resource that is acceptable to all participants (this, the shared goal, could be in conflict with individual goals). Union-management bargaining is a scenario in which a negotiation dialogue may be used in order to reach agreement.
- **Deliberation:** Collaboration to decide on an appropriate course of action to be taken in a particular situation. Again, the "best" course of action for the group as a whole could conflict with individual preferences.
- **Eristic:** This type of dialogue involves the venting of grievances verbally, with the aim of defeating and humiliating the other party. Rather than adhering to logical reasoning, this kind of dialogue is characterised by violent outbursts with the aim of simply "winning" over the other party at all costs. This type of dialogue is used as an alternative to physical violence in human personal relationships, and one would not often wish to model it for use in AI.

Other dialogue types have since been proposed in more recent work, including the *examination* dialogues of Dunne *et al.* in [47], where one party aims to solicit opinions and statements from the other in order to understand their position on the particular topic.

Often, real-world conversations will be a combination of these dialogue types, switching between them regularly throughout the course of the conversation in order to cater for shifts in goals, the dialogue type initiated by the other party, and the specific information shared by the other party.

In [163], Walton describes the aim of deliberation dialogue as being the "agreement on a line of action or policy that [the participants] can implement together", and he gives some examples of dialogues based around proposals for a particular action to be carried out. Although this type of dialogue seems to be the one that applies most naturally to the research question articulated in the previous chapter, other types of dialogue apply too. For example, I consider a government that wishes to implement a policy to reduce the number of people who die as a result of road traffic accidents. The different types of dialogue that Walton and Krabbe identify could be used at different stages of the deliberation process in order to achieve different goals:

- *Information Seeking* dialogue could be used at the very start of the process, when the government wishes to gather information from experts. This information could be related to exactly what the problem is (in the case of this example, this could include statistics on road traffic accidents), and what could realistically be done to address the problem.

- *Deliberation* dialogue may be used for government consultation with citizens to gather their opinions on the current situation and how it could be improved. This type of dialogue would answer the very broad question of "What should we do, and how should we do it?".

- *Persuasion* dialogue is the one considered by this thesis. By using this type of dialogue, governments could present pre-constructed policy proposals to the public, along with persuasive reasons as to why these policies should be implemented, and gather public opinion on the acceptability of this proposal.

Other dialogues may also be used during the process, for example *Inquiry* in order to determine the possible courses of action with relation to any suppliers or other external bodies that are necessary for implementation of the policy. *Negotiation* dialogue may be used to negotiate with external bodies in order to deliver policies that are more appealing to citizens. Alternatively, negotiation could be used between government and citizen to support the refinement of policy proposals.

The use of persuasion dialogue in order to present justifications for action is an area of interest that is described later in Chapter 4 and implemented within the software system that is described throughout the rest of this thesis.

In the next section, I consider the application of Argumentation Theory to Artificial Intelligence.

2.1.2 Argumentation for Computational Systems

In the previous section, I discussed the representation of arguments by examining some of the literature from argumentation theory. Such representations are typically taken from the informal logic literature, and hence are highly structured and relatively close to natural language. In this section, I consider how argumentation theory has been applied to computational systems. Computational representations of arguments typically abstract away from the detailed account of argument described in the previous section, in order to provide mechanisms that allow for computational evaluation of the arguments within a debate.

Computational models of argument have been used in the literature for a variety of purposes in a range of domains, and a number of conferences and journals have been established on this topic (for example, the *Computational Models of Argument*

(COMMA)[2] conference and *Computational Models of Natural Argument (CMNA)*[3] workshop; and the *Argument & Computation*[4] journal).

I now discuss some of the research contributions that have been made to a variety of different domains using computational argumentation.

One of the first applications of computational argumentation to the computer science research area of multi-agent systems was by Parsons *et al.* in [120]. Within this work, Parsons proposes a framework which permits negotiation between agents, and is based on a system of argumentation. The need for negotiation within multi-agent systems arises due to the dependence that agents often have upon one another in order to complete certain tasks, and social ability is defined in [169] as being one of the factors required in order for an agent to be considered "intelligent". As a result, considerable research work has concentrated on the development of argumentation-based approaches to negotiation in multi-agent systems (e.g. [168], [51], [46]). Other applications of argumentation within multi-agent systems include dialogue games to support communication and argument between agents (e.g. [9]).

One particular domain in which significant contributions have been based is AI & Law. The large application of computational argumentation to law is due to the importance of argumentation itself to the domain; a legal case typically centres around two parties who present their arguments in order to persuade a judge that it is their particular argument which is right. The judge then makes a decision of which party to favour based on the arguments presented and the application of the law. Modeling legal reasoning can therefore be seen in terms of modeling of argument. One of the earliest projects in AI & Law was the Taxman project of Thorne McCarty [103], which centered around a famous legal case based upon whether a particular share issue was income or not. The theory of legal reasoning illustrated by this case was implemented as a computer program using LISP, in which a reconstruction of the arguments by both parties in this case was provided. The 1980s brought about the HYPO project of Rissland and Ashley [4], which modelled arguing with cases in the field of US Trade Secrets Law (the work diverged into two strands: Rissland and Skarak's CABARET [147], which identified a set of argument moves and strategies; and Ashley and Aleven's CATO [1], designed to teach the HYPO style of reasoning to law students).

Another important application of argumentation to AI and Law has been in the modeling of legal reasoning as a dialogue game. An early example of this is Gordon's 1994 *Pleading's Game* [59], the purpose of which is to identify the legal and factual issues of a particular legal case. The data of the game is defeasible rules and sentences of first-order logic. There are also four kinds of speech act; conceding, denying and defending claims; and for declaring defeasible rules. The game was designed to identify

[2]http://www.comma-conf.org/
[3]http://www.cmna.info/
[4]http://www.tandf.co.uk/journals/tarc

which aspects of a case were agreed upon and which aspects were disputed. Later argumentation based dialogue games in the legal domain include DiaLaw [87], designed to assist in analysing legal decisions, and ArguMed [157], which supports computer-mediated argumentation. These systems, along with a number of others, are presented in the survey of tools that I conduct in Section 2.2. More recent applications of computational models of argument to law include [172], in which Wyner and Bench-Capon investigate the use of Argumentation Frameworks (described later in this chapter) in capturing important features of legal reasoning. An overview of the use of computational models of argumentation in the legal domain is presented by Bench-Capon *et al.* in [22].

The domain of medicine is another in which argumentation has been successfully applied. In 1993, Fox *et al.* presented their work on assigning statements of confidence to arguments, and showed how this can be applied in order to aid the medical diagnosis process [52]. In [161], Žabkar *et al.* present an approach which combines machine learning with concepts taken from argumentation. The authors describe ABCN2, an argument-based rule learning algorithm which has been applied in the medical domain in order to determine the severity of bacterial infections in geriatric patients. Other recent work in the area of computational argumentation and medicine includes [34], an approach to group decision support using argumentation; [13], in which Atkinson *et al.* present a system which uses practical-reasoning based argumentation to reason about the medical treatment of a patient; and [149], which describes the use of a model called *ProCLAIM* to argue over the suitability of a particular organ for donation.

In this thesis, the application of computational models of argument is concentrated within the domain of e-Democracy. A number of existing applications of argumentation exist within this domain, most of which attempt to cater for the deliberation and decision-making aspects of electronic government. The decision-making process is one that is catered for in numerous publications within computational argumentation, across a wide range of domains. Some examples include [117], where the role of argumentation in the process of decision aiding is considered; and [112], in which the authors investigate how the notion of a social value can be used in order to decide between competing arguments. As this is important to the further work described in this thesis, I now turn to consider exactly what is meant by a *social value* and how this can be applied to argumentation.

A social value defines the motivation for achieving (or avoiding) a particular state of affairs, and social values can be thought of as being promoted or demoted by moving from one state of affairs to another. By way of an example, consider a state of affairs in which John is unemployed. He discusses with his wife the possibility of attending some interviews in order to get a job. John feels that he would be happy to move from a state of unemployment to one in which he has a job, and hence the transition promotes the value "Happiness". He would also earn some extra money, and thus the value of "Personal Wealth" is promoted by the transition. However Jean, John's wife, is also unemployed and would be lonely during the day as a result of John getting a job, and so this transition would *demote* "Happiness" in her opinion. This example demonstrates how an argument in which the factual, objective, elements are consistent (i.e. John is now unemployed, John will search for a job and eventually find employment) can still face conflict when it comes to the elements that are more subjective (i.e. whether the transition between unemployment and employment promotes the value of "Happiness"). Although Jean might agree with the promotion of the "Personal Wealth" value, whether or not she agrees with John carrying out the action of searching for a job depends on whether she ranks the value of "Happiness" higher than that of "Personal Wealth".

The values that can be held by a person (or "audience", a term discussed later in this section) are wide ranging and may be motivated by a number of factors including their aspirations, social factors (for example, values influenced by their friends and family) and environmental factors (e.g. values held by the culture in which they live). Searle discussed disagreement based on the values held by different parties in his book *Rationality in Action* [146], where he states:

> "Assume universally valid and accepted standards of rationality, assume perfectly rational agents operating with perfect information, and you will find that rational disagreement will still occur; because, for example, the rational agents are likely to have different and inconsistent values and interests, each of which may be rationally acceptable." [146, p. xv]

Here, Searle is alluding to the fact that although the factual information of an argument may be agreed upon, the subjective information intrinsic to the argument may still cause conflict. The fact that different agents subscribe to these different "values and interests" does not detract from the rationality of their agreement or disagreement. When conflict arises due to a subjective opinion in real life argumentation, the participants often simply "agree to disagree" - on realising that the other party will not change (and is quite entitled not to change) his or her subjective beliefs or views, they choose to end the argument.

The use of values in the context of argumentation has received significant attention in the literature (e.g. [30]), with one of the most interesting contributions being the book by Perelman titled "Justice, Law, and Argument" [122]. Within this book, Perelman considers how differing decisions can be made as to the outcome of a particular argument based on differing values:

> "If men oppose each other concerning a decision to be taken, it is not because they commit some error of logic or calculation. They discuss apropos the applicable rule, the ends to be considered, the meaning to be

given to values, the interpretation and characterisation of facts." [122, p. 150]

Another important consideration introduced by Perelman is the notion of an *audience* to whom an argument is addressed. Within the context of argument representation and evaluation with respect to social values, an audience is often considered as a group of people who subscribe to a similar set of values and a particular ranking over these values. Perelman and Olbrechts-Tyteca also discuss values and audiences in [121], where Perelman argues that all argumentation must be adapted to an audience, and evaluated relative to the particular audience to which it is presented.

While much of the research described so far in this section concentrates on the theoretical aspects of computational argumentation, there is also a wealth of literature which describes the development of software implementations of computational models of argument. The development of computational tools for decision support has been an active research area in the field of Computer Science for many years (there is a regularly published journal on this topic [48] which commenced publication in 1985), and as a result there are numerous examples of such systems available today. Some of the most relevant contributions are described in detail in Section 2.2. One interesting development is The Argument Interchange Format (AIF) [35], which proposes a specification intended for representation and exchange of data between argumentation tools and agent-based applications. In response to the large number of tools available to support the process of argumentation, the AIF attempts to overcome the "lack of a shared, agreed notation or 'interchange format' for argumentation and arguments"[35]. The proposed framework is expanded by Rahwan *et al.* in [130] in order to create an ontology of arguments which form the basis of their *World Wide Argument Web*, "a large-scale web of interconnected arguments". The same authors go on to present a software tool named *ArgDF*. ArgDF allows users to create new arguments by instantiating a pre-existing schemes, or create a new argumentation scheme to form the template of an argument. Users can also view existing arguments within the ArgDF repository and support or attack them using new arguments. The AIF is discussed further in Section 2.2.3, and the World Wide Argument Web and ArgDF in Section 2.2.4.

2.1.2.1 Abstract Argumentation Frameworks

One method of argument representation is the Abstract Argumentation Frameworks of Dung [45]. The work of Dung is particularly important to this thesis, as Argumentation Frameworks and Value-based Argumentation Frameworks [20] (discussed later) are used in order to evaluate the arguments within the software system that I present in Chapters 5 and 7.

Arguments within these frameworks are evaluated according to how well they defend themselves against attacks from other arguments, thus determining whether they are accepted or rejected. These frameworks have proved to be popular in the representation of defeasible arguments, and a number of extensions have been based upon the foundations laid by Dung.

In [45], an Argumentation Framework is defined as a set of arguments, and a binary relationship representing attacks between arguments. Thus an Argumentation Framework can be formally defined as a pair AF = <*AR,attacks*>, where AR is a set of arguments and *attacks* is a binary relationship on AR. As the frameworks are abstract, the content of the arguments within the framework are not considered, and thus the status of an argument can be determined by considering whether or not the argument is capable of defending itself against attacks from other arguments. Therefore, an argument $A \in AR$ can be considered *acceptable* with respect to a set of arguments S, if (and only if) for each argument $B \in AR$, if B attacks A then B is attacked by a member of S.

A set S is considered to be *conflict-free* if there are no attacks between arguments within the set (i.e. for all arguments A,B within S, A does not attack B). Furthermore, set S is defined as being *admissible* if it is conflict-free, and each argument contained within S is acceptable with respect to the set itself.

Dung goes on to describe the semantics of the framework through several interesting types of admissible set. Grounded semantics is based on the *grounded extension*, the minimal admissible set; preferred semantics on the *preferred extension*, which is defined as the maximal admissible set of arguments within the particular framework; and stable semantics on a *stable extension* which is a preferred extension in which every argument not in S is attacked by a member of S. The preferred extension represents a consistent position within the framework, which can defend itself against all attacks and which cannot be further extended without introducing a conflict. While there is exactly one grounded extension, there may be several preferred extensions. Following this, a *credulous* reasoner can be defined as one who accepts an argument if it appears in *at least one* preferred extension, and a *skeptical* reasoner as one who accepts an argument only if it appears in *all* preferred extensions. Every framework has a preferred extension, which may be the empty set consisting of no arguments, and many frameworks have more than one preferred extension. In the special case where there is a unique preferred extension we say the dispute is resoluble, since there is only one set of arguments that can be rationally accepted.

The formal description of Dung's semantics are omitted from this thesis, but they can be found in [45]. A number of other semantics have also been proposed, of which Baroni and Giacomin provide an overview in [17].

Argumentation Frameworks can be depicted visually as labeled directed graphs, which provides a useful mechanism for visualising the relationship between arguments. A primitive Argumentation Framework is illustrated in Figure 2.2, which shows an Argument Framework in which there are two arguments, Arg1 and Arg2, such that Arg2 attacks Arg1. In this example framework, Arg2 is not attacked by any other argument and it attacks and defeats Arg1, which has no defenders.

Figure 2.2: A Dung Argumentation Framework

A number of extensions and modifications to this work have been proposed (e.g. [104], [16], [8]), and these are discussed in Section 10.4.2.2 of this thesis. One particular extension, Bench-Capon's Value-based Argumentation Frameworks, are used to evaluate arguments in the software system that I develop throughout the rest of this thesis.

2.1.2.2 Value-based Argumentation Frameworks

In this section, I discuss one particular extension to Dung's Argumentation Frameworks that makes use of social values in order to evaluate the arguments within the framework. This work is of particular interest to this thesis, as I go on to describe a software implementation of Value-based Argumentation Frameworks which I have developed in Chapter 5. One of the motivations behind the introduction of value-based argumentation can be seen in the quote from Perelman's book given in Section 2.1.2, where he alludes to differences in opinion as often being a product of differences in the values subscribed to by the conflicting parties.

By allowing arguments to be evaluated according to the values that they promote, VAFs enable distinctions to be made based on the value preferences of the particular audience to which the argument is presented. In Dung's model of Argumentation Frameworks, defeat of a position was automatic in the case that its attacker was not defeated by another argument. However in a VAF, where a particular argument (Arg2) is attacked by another argument (Arg1) which is not defeated, the success of the attack of Arg1 upon Arg2 is not guaranteed. Rather, the attack is only successful if the social value promoted by Arg2 is not preferred to the value promoted by Arg1, and this preference ranking of social values is specific to an audience. Hence the success of the attack is dependent on the value preferences of the particular audience to which the argument is presented, and the notion of *defeat for an audience* arises. In the case of Arg1 and Arg2 promoting the same value, then Arg1 is defined as defeating Arg2. Thus, for any given audience a defeat relation may be derived from the attack relation and the preferred ordering of values for the particular audience.

A VAF is defined in [20] as $VAF = \langle AR, attacks, V, val, P\rangle$, where AR is a finite set of arguments, *attacks* is an irreflexive binary relation on AR, V is a non-empty set of values, *val* is a function mapping elements of *AR* to elements of *V* and *P* is the set of possible audiences. An argument *A* relates to value *v* if accepting *A* promotes *v*.

Recall that the preferred extension of one of Dung's frameworks was defined as the maximal admissible set of arguments in the framework. The preferred extension of a VAF (for a particular audience with a particular value preference order) is defined as "the maximal subset *S* of arguments such that no argument in *S* defeats any other argument in *S* given the value ordering of that audience, and all arguments in *S* are acceptable to that audience with respect to *S*" (i.e. for any argument *A* in *S*, if *A* is defeated by an argument *A'* that is not in *S*, then there exists an argument in *S* that defeats *A'* based on the value ranking of the audience). Furthermore, Bench-Capon demonstrates in [20] that the preferred extension for any given value ordering is both unique and non-empty, provided that there are no cycles in a single value contained within the framework. This is in contrast to Dung's frameworks in which there may be multiple preferred extensions.

Bench-Capon introduces *objective acceptance* in VAFs, which occurs when an argument is acceptable to any audience regardless of their value preferences. *Subjective acceptance* of an argument occurs when the acceptability of the argument is dependent on the value preference of the audience. An argument which is neither objectively nor subjectively acceptable (for example, one attacked by an objectively acceptable argument with the same value) is termed an "indefensible" argument, i.e. one that can never be acceptable.

A basic VAF is illustrated in Figure 2.3. It illustrates the same attack structure as the Dung Argumentation Framework in Figure 2.2 (Arg2 attacks Arg1), but the framework additionally represents the social values that are promoted by each argument. If we now consider an audience that prefers Value2 over Value1, then the attack of Arg2 on Arg1 succeeds, and Arg1 is defeated. This is shown in Figure 2.4. Conversely, if we were to consider an audience that prefers Value1 over Value2, then the attack of Arg2 on Arg1 does not succeed. In this case, Arg1 is not defeated for the audience with this particular value ranking.

Figure 2.3: A Bench-Capon VAF with two arguments

Another scenario that I will consider is where an argument is attacked by more

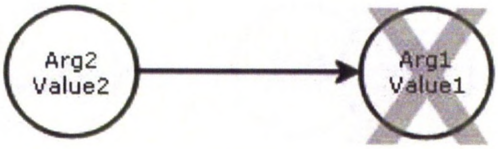


Figure 2.4: A Bench-Capon VAF with two arguments, where the audience prefers Value2 over Value1

than one other argument. This is shown in Figure 2.5. A VAF allows us to cater for an audience that prefers Value1 over both Value2 and Value3, in which case the attacks of Arg2 and Arg3 on Arg1 do not succeed. VAFs in this format, with one central node surrounded by a number of attackers, are particularly relevant to this thesis as VAFs conforming to this structure are used in the software implementation described in Chapter 5.

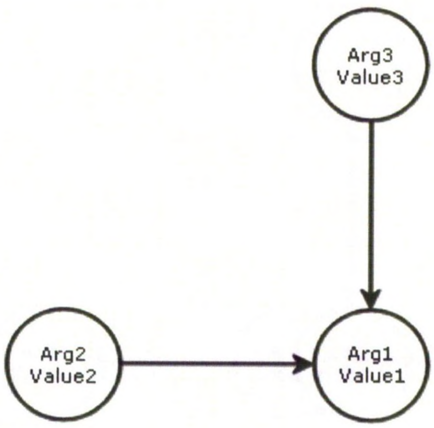


Figure 2.5: A Bench-Capon VAF with three arguments

Once an argument has been evaluated within a VAF, and the unsuccessful attacks have been removed, the framework "collapses" into a standard Dung Argumentation Framework. This is illustrated by the framework in Figure 2.6[5], where the uppermost framework is a Bench-Capon VAF (the cycle present in the framework means that it does not have a unique preferred extension when considered as a Dung framework). If

[5]This example is derived from one presented in the lecture notes of Katie Atkinson. I would like to thank Dr. Atkinson for giving me permission to use this example.

the upper framework is evaluated for an audience who prefer V_1 to V_2, the preferred extension illustrated in the lower framework is obtained. One can see that this acyclic framework can now be represented as, and evaluated in terms of, a standard Dung Argumentation Framework.

Recently Modgil introduced the notion of Extended Argumentation Frameworks (EAFs) which enable argument about preferences [104]. Within an EAF arguments may pose attacks on attacks, in addition to attacks on other arguments. This effectively generalises all attempts, such as VAFs, to formalise a distinction between attack and defeat. Several approaches, including VAFs, are recast into EAFs in [105].

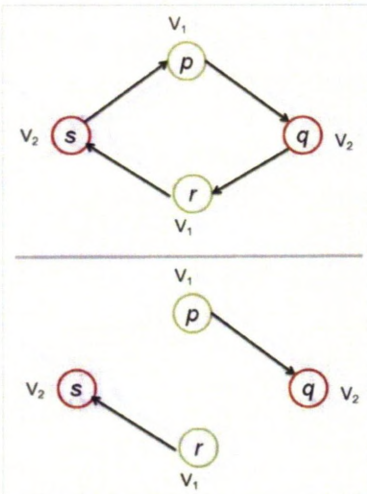


Figure 2.6: A Bench-Capon VAF which collapses into a Dung AF

2.2 Argumentation Support Tools

Having described the argumentation theory literature that is relevant to the research question posed in this thesis, I now turn to consider some of the most significant software implementations developed to support the process of argumentation. Such software tools may be based on structures taken from the argumentation literature, the most significant of which I described in the previous section, or may be less formal and rely on the users themselves to structure the information within the system.

Bex *et al.* define a further categorisation of argumentation support tools in [26], into *knowledge-based systems* and *sense-making systems*. Knowledge-based systems contain knowledge about the domain, and can reason with this knowledge in order to solve a certain concrete problem. In contrast, sense-making systems simply assist humans in making sense of a problem, with no reasoning mechanisms employed in order to "solve" the problem. It is the former of these types of system that are most often accompanied by an underlying formal model of argument, to allow for the knowledge within the system to be reasoned with according to a particular formalism. Sense-making systems sometimes employ particular models in order to visualise the data within the system; however much of the rigidity of formal structures is not required in order to perform basic visualisation of arguments and the positions between them. Sense-making tools are alternatively known as "argument mapping tools" (e.g. [56], [57]), as they facilitate the process of mapping out the various positions within an argument.

Like argumentation itself, the tools available to support the process of argumentation were developed for a range of domains including law, medicine, government and commerce. As the domain of law requires the development of critical thinking skills in order to make sense of arguments, this has proved to be a domain for which many systems have been developed as "argumentation assistants" for the legal profession (e.g. ArguMed, see Section 2.2.5.3). A variety of tools have also been developed to support the process of collaboration in business meetings to assist and inform the mapping of ideas and, ultimately, to influence decision making. QuestMap and Rationale, described in Section 2.2.5.15 and Section 2.2.5.16 respectively, are two examples of such tools.

In [78], Kirschner *et al.* provide a comprehensive review of the state-of-the-art in computer-based visualisation of arguments, including the software which has been developed to support this process and the underlying roots of current research in this area. In this section of my thesis, I consider the range of available tools and some of the most significant underpinnings of such systems. The software tools to support argumentation in the domain of e-Democracy are of particular interest to this thesis, and hence are described separately in Section 3.3.

Firstly, I consider some of the theoretical foundations of software tools in the domain of computational argumentation. I begin by discussing the Issue Based Information System of Kunz and Rittel, which was developed in the 1970s but forms the basis of many more recent tools. I then consider Online Dispute Resolution, for which software tools have been developed to support the dispute mediation online. I conclude by describing the Argument Interchange Format and the World Wide Argument Web, two areas of research which attempt to define common standards for the computational representation of arguments so that they can be shared between different domains and applications.

2.2.1 Issue-Based Information Systems (IBIS)

Issue Based Information Systems (IBIS) is a model of argument introduced by Kunz and Rittel in [142] as an argumentation-based approach to tackling wicked problems.

"Wicked problems" can be defined as those which lack a single, agreed-upon formulation; require complex judgments about the level of abstraction to represent the problem; do not have clear stopping rules; have "better or worse" solutions rather than "right or wrong" ones; and have no measure of success [78]. The IBIS method has been used as the basis for a number of the implementations described later in this chapter. Issue-based Information Systems were introduced to support the planning of political decision processes, and "guide the identification, structuring, and settling of issues raised by problem-solving groups, and provide information pertinent to the discourse" [142].

The IBIS model allows for representation of the *issues* arising in a particular problem, which may consist of a number of different *positions*. An issue is generally posed in the form of a question, often originating from a controversial statement that has been made. *Arguments* can then be created in support or defence of the positions until the issue is settled (by convincing the other party, or using some formal decision procedure).

In IBIS, a discussion begins with someone posting an issue node containing a question such as "How should we do x?". This person may also post a Position node proposing one way to do x. Other users can post their own position nodes which they may support with their own arguments. Others may post other positions, or arguments, which support or object to any of the positions entered into the system so far.

IBIS also supports acquiring arguments from external sources; for example, *questions of fact* can be directed to experts and the response obtained can be fed back into the system as an issue. Literature can also be obtained from "documentation systems" (e.g. literature in support of a particular position, or a reference for a particular fact) and used as an issue.

All of the elements of IBIS described so far are linked together using nine different kinds of link, including *Responds-To*, *Supports*, and *Objects-To*. Figure 2.7 illustrates the types of node available within the model, and the possible links between them.

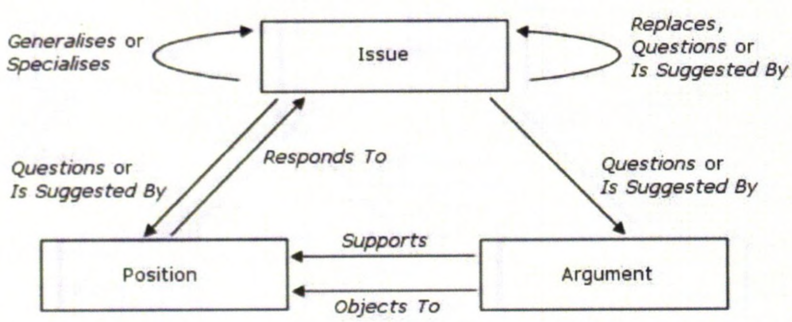


Figure 2.7: Objects and relationships in an IBIS model[41]

There is no particular method of registering when an issue has been resolved by agreement upon one of the positions within the system. The goal of the system is for each stakeholder in the discussion to understand the elements of others' proposals, and perhaps even to persuade others of his own point of view. Using only the moves available within the system makes it harder for unconstructive discussion to take place (for example, repeating arguments that have already been made, and name calling).

A variety of implementations of IBIS exist in the literature, some of which are based directly on the IBIS method introduced by Kunz and Rittel, while others are based on extensions to the original system. Examples include gIBIS, described in Section 2.2.5.13, and rIBIS, an IBIS-based prototype system to assist design teams in capturing design rationale [135]. More recently, software systems to support visualisation of argument and decision making have been based on the foundations set by IBIS, including Zeno (see Section 3.3.2.1), CoPe_it! (see Section 2.2.5.9) and QuestMap (see Section 2.2.5.15).

In this section I have considered IBIS, a model of structuring argument which dates back to the 1970s. Despite the age of the method, many of the argumentation tools used today, and described in this chapter, are based on this model.

2.2.2 Online Dispute Resolution

Online Dispute Resolution, or ODR, uses online technology to resolve disputes between two or more parties with opposing views. It is of relevance to the work presented in this thesis as it involves reaching conclusions on particular matters of debate. Some tools for ODR provide facilities for the parties to reach consensus on the topic under scrutiny themselves, whilst others involve a third party in order to mediate the discussion.

Online Dispute Resolution is often performed by specialist companies, examples of which include Cybersettle[6] and SquareTrade[7] (recently discontinued), although the application of ODR is in many well known websites; for example SquareTrade, until recently, provided the dispute resolution service for the eBay online auction website, to mediate disputes between sellers and buyers. ICANN (Internet Corporation for Assigned Names and Numbers) are another example of an online business who have created their own dispute resolution services to mediate disputes between two parties who both have an interest in the same Internet domain name.

A number of different methods exist to perform dispute resolution online, and these can be broadly categorised as those methods which are based on automated negotiation (i.e. those methods which employ computational methods of negotiation) and assisted negotiation (in which technology plays the role of a mediator in the dispute between the parties involved). The Cybersettle service mentioned above is based on the *double-*

[6]http://www.cybersettle.com
[7]http://www.squaretrade.com

blind bidding method of dispute resolution, in which both parties make "offers" and "demands" of the amount of money in dispute, and each offer and demand is kept secret from the opposing party until an agreement is reached (or the two offers come within a close margin of each other).

SquareTrade is an example of a service which offered assisted-negotiation based dispute resolution. The system allowed seller and buyer to communicate in order to attempt to resolve their differences, and provided a web-based interface with limited free-text arguments, encouraging the proposal of agreements and setting of deadlines until both parties were happy with the outcome.

The BEST-project, described in [83], involves the creation of a system within AI and Law to assist laypersons in judging their legal position in damage dispute cases. By determining their legal position, users of the system are able to see whether they are legally considered to be liable for certain damages or whether another party is liable. It also allows the parties to determine how much room for negotiation is available in settling the claim.

The BEST-project aims to facilitate the first step of the three-stage model of effective resolution of online disputes set out by Lodder and Zeleznikow in [88]:

- Determining a BATNA (Best Alternative To a Negotiated Agreement), to help the disputing parties determine what will happen if the dispute is not resolved

- Allowing parties to communicate using dialogue techniques

- Using game theory techniques that employ compensation/trade-off strategies to attempt to resolve remaining issues in dispute.

The BATNA identifies the "result that should ideally at least be reached in the negotiations (the threshold)"[83], and the BEST-project aims to develop a BATNA in order to assist both parties in a dispute to see where they stand legally and determine what compensation they may be able to claim (if any) before seeking professional legal assistance. The system is based on case-law in the area of Dutch tort law, and possesses the capability to detect relevant law articles based on a structured case description, which the system assists the user in creating.

The domain of Online Dispute Resolution is related to the research areas explored by this thesis. Both share in common the aim of reaching conclusions based on the possibly differing opinions of the parties involved. However, whereas dispute resolution is intended to support intense and highly involved communication between two parties, the democratic deliberation investigated by this thesis should support communication by a large number of users who may all have conflicting or similar views. In order to encourage the participation of citizens, the communication supported by deliberation tools should not be more intense or time consuming than necessary.

The discussion of dispute resolution presented here is intended to introduce it as a related research area. Although the aims of the research areas are related, the process by which the aim is reached is rather different, as motivated by the discussion given above. For this reason, I do not consider Online Dispute Resolution in any more detail.

2.2.3 Argument Interchange Format

The Argument Interchange Format (AIF) was introduced by Chesñevar *et al.* in [35]. The problem addressed by the AIF is stated by the authors as being the "lack of a shared, agreed notation or 'interchange format' for argumentation and arguments". This issue arises from the numerous different representations of argument, all based on different formalisms from argumentation theory (or not based on any formalism at all), that arise in diverse set of applications and databases of arguments.

Examples of existing mark-up languages can be found in many of the systems that I describe later in this section. For example, the Compendium tool described in Section 3.3.2.4 is based on the IBIS method discussed in the previous section. Meanwhile, the Araucaria system (Section 2.2.5.1) is based on Reed and Rowe's Argument Markup Language (AML) [133], an XML-based language designed for the markup of analysed human argument. The mark-up languages employed by these existing tools are tailored to the particular application, and hence the inter-operability between such tools is typically limited or impossible.

The AIF is an international effort which attempts to overcome this problem by introducing standards for the representation and exchange of arguments, which could eventually lead to the automated exchange of arguments between intelligent software agents. It is built on the assumption that entities of an argument can be represented using a directed graph, which the authors call an "argument network". An argument network consists of a set of nodes, which are connected together by edges. Nodes can be of two distinct types; *information nodes*, or I-Nodes, which hold pieces of information or data related to an argument; and *scheme nodes* or S-Nodes, which represent arguments' schemes.

Information nodes are used to represent data such as a claim or a premise of an argument - i.e. data that is passive. Conversely, scheme nodes are used to capture the schemes of argument, which can be considered as domain-independent patterns of reasoning. Three different kinds of scheme are introduced in [35]: *rule of inference application* (RA), *preference application* (PA) and *conflict application* (CA). Intuitively, RA nodes represent the application of rules of inference, CA nodes capture applications of criteria defining conflict (for example, between a proposition and its negative form), and PA nodes are applications of criteria of preference among evaluated nodes.

Edges connect two nodes together. However, unlike nodes themselves edges are not typed, and their semantics are defined with respect to the two types of node which are connected by the edge. For example, an edge from an I-Node to a PA-Node indicates that the "I-node data [is] used in applying a preference", whilst a connection in the opposite direction indicates that the PA-Node is "applying a preference over data in the I-Node" [35]. The semantics of all possible connections between two nodes are defined by the authors (note however that connections between two I-Nodes are not permitted in the AIF). The complete semantics are detailed in [35].

One of the extensions to the AIF that is most relevant to the work presented in this thesis is presented by Rahwan *et al.* in [128]. In this paper, the authors attempt to allow for the representation of the argumentation schemes of Walton (described in Section 2.1.1.2) in the AIF. The schemes are represented using class instances, and the authors introduce typed edges to make the representation of different types of relationship more explicit. A class named "SchemeDescription" is introduced for handling the main type of the schemes, whilst three subclasses are also introduced: *ConflictScheme*, *PreferenceScheme*, and *RuleScheme*.

Figure 2.8 illustrates the representation of the scheme instance for the "Argument from Expert Opinion" argumentation scheme, which is listed in full as AS3 in Appendix C of this thesis. Some of the critical questions associated with the scheme pose exceptions, and these are represented using the "ConflictScheme" structure introduced by the authors. Other critical questions challenge the presumptions, which are also represented explicitly in the network.

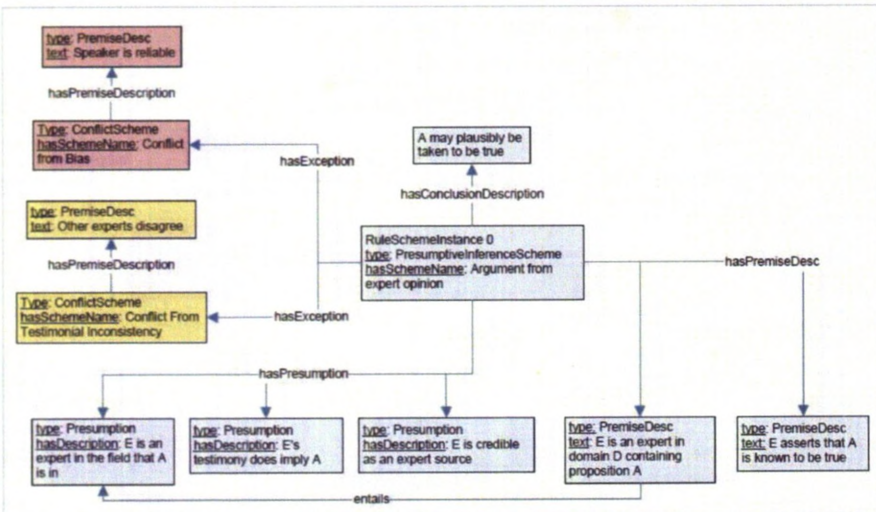


Figure 2.8: Representing the Argument from Expert Opinion in the AIF [128]

A number of other extensions to the AIF have been proposed. In [106], Modgil and McGinnis propose an extension to the AIF which allows the characterisation of argumentation based dialogues. In order to achieve this, the authors represent locutions as content in I-nodes and interaction protocols in a new scheme node type, which they name the *protocol interaction application* node. A later piece of work by Reed *et al.* also attempts to represent dialogic argumentation by extending the AIF [134], in an extension which they name AIF$^+$. The aim of AIF$^+$ is to extend the AIF by allowing representation of argumentation protocols and dialogue histories. A further extension to the framework in which *context nodes* are introduced in order to formalise the context of each claim or scheme application, in order to aid their re-usability, is described in [86].

One potential future use of the AIF is in the *Arguing Agents Competition* (AAC), a project being run by the University of Dundee. The Arguing Agents Competition is "designed to provide an open forum in which agents can compete using various argument dialogue protocols, where moves and arguments can be evaluated through a variety of argument computation engines"[8]. This competition between various agents motivates the need for a common model of argumentation which can be used and shared between all of the agents taking part in order to achieve a consistent representational framework of argument. In [167], the authors propose that AIF (and AIF$^+$, described earlier) could be implemented within the AAC to enable a uniform approach to dealing with arguments and their interactions.

The authors of a number of the argumentation support tools, discussed later in Section 2.2.5, have considered how the AIF could be implemented within their systems.

The Argument Interchange Format, although still a young and developing method of argument representation and communication, provides an interesting insight into how standards can be applied to arguments in order to facilitate their interoperability across different applications and domains. Rahwan and Reed provide a review of the latest developments to the Argument Interchange Format in [127].

In the next section, I discuss some research which is based on, and develops further, the groundings of the AIF.

2.2.4 The World Wide Argument Web and ArgDF

The World Wide Argument Web (WWAW) is promoted by its authors as a "large-scale web of inter-connected arguments posted by individuals to express their opinions in a structured manner" [130]. Whilst the World Wide Web has provided a means for widespread access to information and the sharing of information between humans and machines, the World Wide *Argument* Web aims to allow mass-collaborative editing of structured arguments on the web, such that they can be utilised in a variety of software applications spread across different domains.

The aim of the WWAW is to make use of the AIF in order to allow humans, software, and agents to create, share, and analyse arguments over the Internet in a common

[8] Arguing Agents Competition: http://www.arg.dundee.ac.uk/?page_id=97

format. This is in contrast to many of the other tools which already exist (and are described in the following sections of this literature review), which use individual formats in order to share the arguments within the application, and hence such arguments are inherently not interoperable (e.g. *Araucaria* and *Compendium*).

The WWAW is based on an extension to the Argument Interchange Format (AIF) which allows for arguments to be expressed with a structure based on Walton's argumentation schemes (introduced in [128]).

The long term vision of the WWAW is to provide a system through which arguments can be specified and linked to other arguments, in addition to allowing arguments to be queried and ordered by their strength. The strength of any particular argument is calculated according to the quality and quantity of its attacking and supporting arguments. The WWAW is built on the strengths of the Semantic Web [84], and its ontology is implemented using the RDF (Resource Description Framework) Schema Semantic Web ontology language. In [130], the authors present a representation of the AIF in terms of an RDF Schema.

ArgDF is described by the same authors as a pilot application that makes use of the AIF-RDF ontology introduced by the World Wide Argument Web. It is intended as a system to demonstrate the capabilities of the AIF and WWAW, and the authors envisage that future applications could be more feature-rich. ArgDF allows users to create and query arguments that are annotated using different argumentation schemes. Users can set up their argument to attack or support an element of an argument that already exists, or even use a piece of a pre-existing argument to create a new one. In addition to annotating their arguments using pre-existing argumentation schemes, users can also create new schemes to be used within the system.

To create an argument within ArgDF, the user must choose which of the existing argumentation schemes he wishes to use to construct his argument (or to create a new argumentation scheme). The generic form of the argumentation scheme is then displayed to the user, to guide him in instantiating it with the particular premises and conclusion relevant to his argument.

All of the existing expressions (premises and conclusions) used within the system are stored in the repository, and the user can view and then choose to Support, Attack, or Inspect any of the expressions. When a user chooses to support an existing premise, then the premise becomes a conclusion of one argument whilst being a premise of another, thus permitting the chaining of arguments within the system. To create a support or attack, the user first must choose the argumentation scheme that will be used to create the supporting or attacking argument, and then instantiate the scheme (as per creating a new argument, described above).

Users can search arguments within the ArgDF repository by specifying some text which is to be found in the premises or conclusion of the argument. The user can also choose whether the search should be performed on premises that are *for* or *against* the specified conclusion, or both. Users can also filter the results according to the particular argumentation scheme used.

It is worth noting that ArgDF does not provide any facility for evaluating the arguments stored within its repository; rather it is intended as a tool to demonstrate the abilities of the WWAW to construct, chain, and store arguments.

Although the AIF, and the resulting development of the World Wide Argument Web and ArgDF, present themselves as an interesting contribution to the field which could potentially go on to provide a method of delivering uniform representation of arguments, very few fully implemented systems yet exist. In order to provide the capability for arguments to be easily and effectively analysed in terms of Argumentation Frameworks, the software system that I describe throughout the rest of this thesis is based on a properietry argument format. My system does not require the interaction of arguments with other agent-based systems and hence the implementation of an AIF-based structure for arguments would likely be time-consuming with little or no benefit. The structure itself has no support for any reasoning or evaluation over the arguments stored within the system, which is the main focus of the software system which I implement.

2.2.5 Survey of Software tools

I now go on to present a survey of some of the computational software tools available to support the process of argumentation. Most of these tools draw upon scholarly research into computational models of argument, although the degree to which arguments within the tool are structured varies considerably. Generally, those tools which support some degree of computational analysis of the arguments within the system are highly structured, whereas those which simply map out the various arguments and positions may not be so highly structured.

I discuss a range of tools in alphabetical order, beginning with Araucaria. I conclude in Section 2.2.5.20 with a round-up of web-based tools which are worthy of consideration, but are not highly related to the research aims of this thesis.

A further discussion of argumentation tools developed specifically for use in e-Democracy is presented later in Chapter 3.

2.2.5.1 Araucaria

The focus behind Araucaria [144], an open-source application developed in Java, was on software to support both teaching and research in argumentation theory. It is an argument reconstruction and mapping tool.

In the Araucaria user interface (shown in Figure 2.9), the left-hand pane shows the original natural language text of an argument. Selecting part of the argument and dropping it into the right-hand pane creates a node which corresponds to the text. A number of actions can then be carried out to structure and combine the nodes.

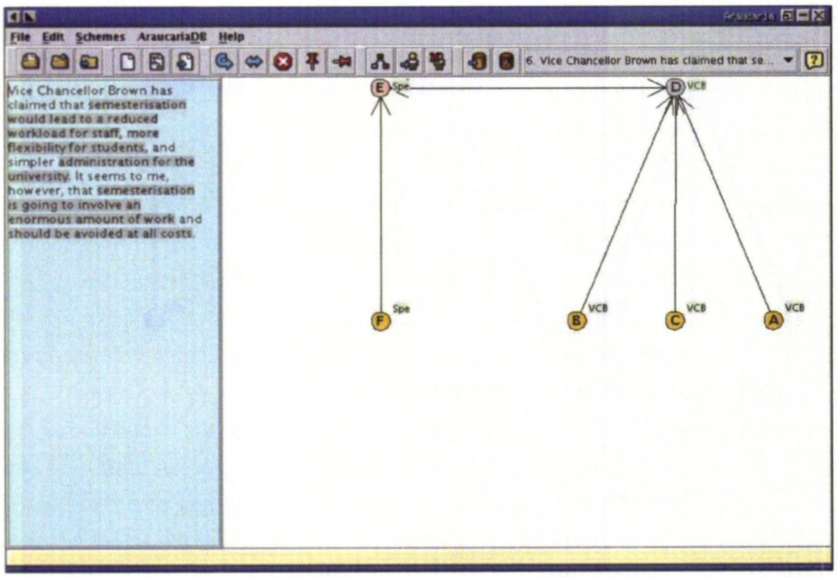


Figure 2.9: The Araucaria user interface

The environment provided by Araucaria is suited to analysis (i.e. it is assumed that a sample text is analysed to produce a diagram). In order to save the text, diagram, and relationships between them (to allow future modification and manipulation), Argument Markup Language (AML) is used. Implementation of AML employs XML, which provides an open standard for argument description.

AraucariaDB is an online database of arguments, which can be utilised in a number of ways through the Araucaria software tool. Users can search through the online repository using a variety of different criteria (including the argumentation scheme used to instantiate the debate, or a text string in the body of the argument). Users can also upload arguments that they have constructed using Araucaria to AraucariaDB.

One of the aims in developing the Araucaria software was to ensure that argumentation schemes were coherently integrated. A user-customisable set of schemes are provided with which to analyse arguments. Araucaria supports visual representation of arguments in terms of "standard" diagrams (a tree with the conclusion of the argument as the root node), Toulmin diagrams, or Wigmore diagrams [143].

A wide range of application areas have been identified by the authors for the application. The first is in Pedagogy, the teaching of critical thinking skills. The authors also suggest that the application could be used in public interaction with arguments, to involve people in public policy decision making.

One of the issues with tools such as Araucaria is that they do not apply any semantics to the text that is entered by users, and thus users can enter any text that they like in order to construct an argument from. Users who are not familiar with the way in which the arguments should be constructed could quite easily enter data incorrectly into the system and thus produce a diagram which does not accurately reflect a coherent argument. This issue is one that must be overcome in systems for e-Democracy, the users of such tools being laypersons who may not be familiar with the underlying structure of argument being employed in the tool. The research that I present later in this thesis addresses this issue by guiding the user through the argument structure, posing simple questions in order to construct an argument, rather than leaving the user to construct it himself.

2.2.5.2 ArguMap

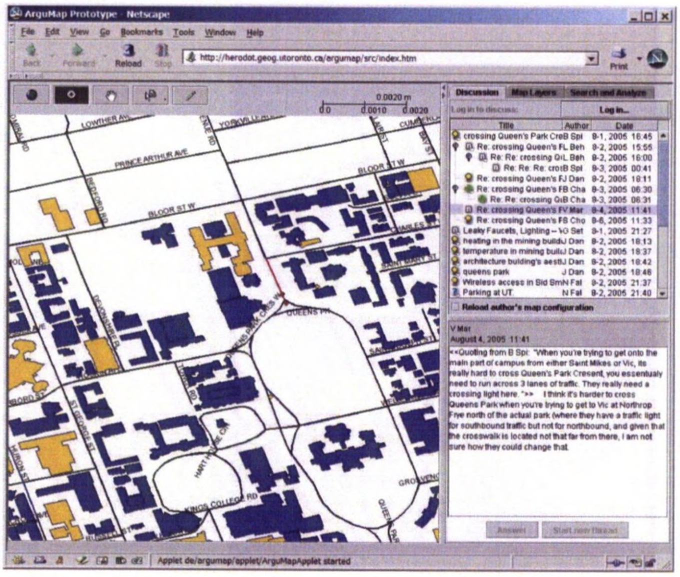


Figure 2.10: The ArguMap user interface

Argumentation Maps, introduced in [139], were developed to support geographically referenced discussions. Argumentation Maps make geographic references in discussion contributions explicit and use them to link textual messages to maps.

When used for decision-making in spatial planning, Argumentation Maps are set up by a provider (e.g. a city planning department) and used by participants in planning procedures. Participants could be laypersons or planning experts.

The aim of an Argumentation Map implementation is to provide a single user interface which implements both the map and the discussion. The discussion should provide a balance between *structure* and *simplicity*. Implementations are usually server-client based, where the server holds the debate data in a database and clients can access it.

A web-based Java Applet has been developed, named ArguMap [77], that integrates both mapping and a discussion tool. The discussion component of the tool uses the tree-structure of a newsreader, and uses a server-side database for storage. Users can mark their contributions as a *question, suggestion, pro, contra* or *neutral*. Although geographical-based discussion is not directly related to the topic addressed by this thesis, there are many similarities between the process of gathering opinions related to government policy proposals and the discussion of planning proposals. However, the ArguMap application does not support any reasoning over the data collected from users; rather, it serves as a repository of discussions related to the topic. This has the disadvantage that, when a large volume of responses are received, it becomes difficult to draw conclusions from the data.

In the software system that I develop, the data collected is reasoned over in order to assist with the visualisation of evaluation of responses in order to make the conclusions that can be drawn from the resulting data explicit.

2.2.5.3 ArguMed

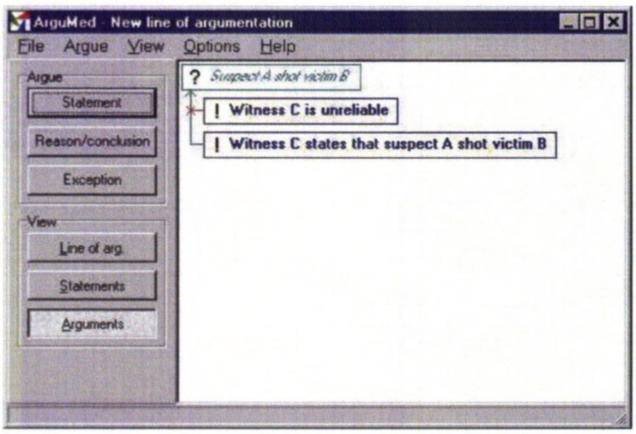


Figure 2.11: The ArguMed user interface

ArguMed, introduced in [157], is an example of a system for computer-mediated defeasible argumentation. This is in contrast to systems for automated reasoning. The latter performs reasoning tasks for users whereas the former play the role of mediator by keeping track of arguments and the justification status of statements.

The argumentation theory underlying ArguMed is based on the CumulA-model by Verheij [156]. Unlike the CumulA-model, which has a general notion of defeat, defeat in ArguMed is only of the undercutter type. CumulA is a procedural model of argumentation with arguments and counterarguments. It is based on two assumptions:

1. Argumentation is a process during which arguments are constructed and then counterarguments adduced.

2. Arguments are defeasible - whether they justify their conclusion depends on the counterarguments available at the current stage.

The defeat status of an argument in CumulA depends on the structure of the argument, the attacks by counterarguments, and the argumentation stage (argumentation stages represent arguments and counterarguments in the system, and the status of them). The authors note CumulA's limitations:

1. The underlying language is completely unstructured - it contains no logical connectives, no quantifiers, and no modal operators
2. The role of rules in argumentation in CumulA is not clarified

ArguMed is a successor to the Argue! system. The authors note that the Argue! system had a user interface and underling argumentation theory that were hard for users to grasp initially. In response to these problems, the UI of ArguMed is template-based, allowing users to construct arguments by filling in templates that correspond to argument patterns. The system uses dedicated templates for different types of argument moves.

Whereas some existing systems are issue-based, ArguMed allows free argumentation. This means that not only are new conclusions inferred, but also reasons are adduced ("backwards argumentation"). The system allows three types of argument move:

1. Making a statement
2. Adding a reason and its conclusion
3. Providing an (undercutter-type) exception

Each statement in the system has a justification status; justified, unjustified, or neither. After each argument move, the system computes the justification status of each statement.

The ArguMed software allows 4 views of the argumentation session:

1. **Line of argument**
2. **Statements**
   All statements made by the user are presented
3. **Reasons**
   All reasons added by the user are shown, with their conclusions
4. **Arguments**
   The arguments that can be constructed on the basis of the current user input are shown

A comparison of ArguMed to other systems, including the Zeno system described in the next chapter of my thesis, is presented in [157]. One of the main differences between ArguMed and some of the other systems that I describe here is that ArguMed is not issue based, which is in contrast to systems such as gIBIS.

Although the ArguMed system is based upon templates, which are intended to make the process of entering arguments into the system easier, the tool still requires the user to have knowledge of some argument concepts (terms such as "conclusion", "exception", and "statement" are used throughout the tool). Therefore it is not suited to use by those who do not have a basic knowledge of argumentation. Additionally, it would be difficult for a tool such as ArguMed to be used by more than a small group of people; although the tool supports some degree of automated reasoning, the arguments which lead to the conclusions being drawn would become confusing if the interface contained a large volume of arguments. Also, as the interface allows users to make their own mind up as to whether their argument represents a statement, a conclusion, or an exception, the arguments within the system could become inconsistent.

Although these issues might not be of concern in the particular domain to which this system is orientated, it would be of concern in e-Democracy, where a large volume of laypersons would be using the system.

2.2.5.4 ArguNet

ArguNet [25] is an open-source software suite for reconstruction and visualisation of complex debates. It is a client-server application in which arguments are stored in XML format on a central server.

Within ArguNet, arguments are reconstructed as premise-conclusion structures and mapped as a directed graph. Complex arguments are visualised as colour-coded maps, where green arrows represent support and red arrows represent attack between arguments.

ArguNet does not impose any restrictions on the inference patterns leading from premise to conclusion, so argument reconstruction does not need to be based on classical formal logic.

The software suite consists of two tools; the first is the argument editor which allows reconstruction of debates in varying degrees of detail. The argument editor can be used as a collaborative learning and research environment. The second tool is Argunet Navigator, a browser-oriented presentation tool. The aim of the tool is to help non-expert users, who may not be acquainted with a complex debate, "to form rational beliefs" regarding the issue in question.

As the Navigator tool can be used to make debate reconstructions available to the public, the authors speculate that it may be useful in e-Participation contexts. However the authors do note that the argument maps depicted using the software are not easily understood by non-expert users [25]. At the present time (August 2010), there are few arguments published to the ArguNet website, and the arguments that are published are not based around e-Democracy topics. It is therefore difficult to evaluate how useful the system would be in the context of e-Democracy and e-Participation.

2.2.5.5 BankXX

BankXX [140] is an application for use in the law domain to generate arguments in a "bottom-up" fashion. This involves searching through a knowledge base for information that could contribute to an argument, gathering the information to create an argument from the ground up.

Creating arguments in this way may be useful where the argument creator does not have the expertise to provide a top-down view of the argument, and uses the tool to dig up information and tries to create an argument from the findings.

The BankXX system models the process of creating an argument through legal research as a heuristic search for relevant cases, theories, and other basic information. The information collected is analysed and amalgamated into an argument.

The case base in BankXX consists of a semantic network whose nodes represent cases and legal theories, and labeled links represent connections between nodes. The network is referred to as a case graph, and the case graph is partitioned into spaces. Nodes within the case graph are highly interconnected, both by links within spaces and cross-space links.

The goal of BankXX is to examine the nodes of the case-domain graph to provide information that may be used to support a legal argument. The examination is performed using a heuristic search.

Although a contribution to the research area as a whole, BankXX is not particularly relevant to the research aims of this thesis which concentrate on gathering public opinion on arguments put forward by the government. Although BankXX was created for the domain of law, systems like BankXX which allow for arguments to be created in a "bottom-up" fashion are useful for the creators of debates to construct their arguments.

2.2.5.6 Carneades

Carneades [61] is an open-source tool developed as part of the European Estrella project. The aim of the project was "to develop and validate an open, standards-based platform allowing public administrations to develop and deploy comprehensive legal knowledge management solutions"[9].

The Carneades tool "supports a range of argumentation tasks, including argument reconstruction, evaluation and visualisation". The current version of Carneades supports *persuasion* dialogues - where two or more participants try to resolve a difference

[9]Source: http://www.estrellaproject.org/

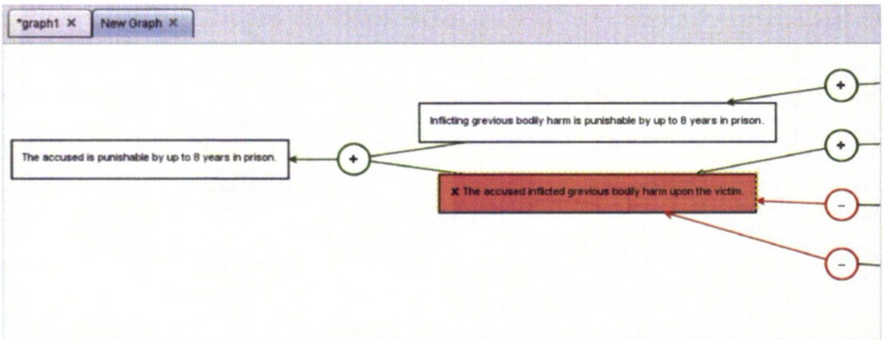


Figure 2.12: A Carneades argument graph

of opinion by trying to persuade the other(s) to adopt their own point of view. This is in contrast to some other systems such as Zeno, which is based on IBIS and designed for *deliberation* dialogues.

Arguments in Carneades are defeasible, and are designed to model instantiations of argument schemes. Carneades is designed to be an open integration framework for various kinds of argumentation schemes, using whatever kind of knowledge representation is appropriate for each scheme.

The argument graphs used in Carneades have two kinds of nodes; statement nodes and argument nodes. The user is allowed to choose the proof standard to be used to judge the acceptibility of each statement that is added to a graph, and arguments can be either for or against the statement. The user can additionally choose the "weight" of the argument, which must be between 0 and 1. Although these mechanisms are useful and allow the system to perform analysis of the arguments entered within the system, they rely on the user to enter arguments correctly in the first place (by correctly choosing statements, arguments, and premises). Therefore, users without a significant understanding of the underlying argumentation are unlikely to be able to use the system effectively.

Premise nodes within Carneades are divided into three types: *Ordinary*, for which a supporting argument must be provided; *Assumptions*, for which an argument must be provided if requested; and *Exceptions*, which can be ignored unless the opponent provides an argument for them. Although the inclusion of these different premise types could be thought of as making the process of argument richer and more expressive, including these concepts in a system designed for use by laypersons is likely to introduce usability issues caused by a lack of understanding of the underlying model of argument.

2.2.5.7 Climate Collaboratorium

Climate Collaboratorium [79] is a system which uses a combination of Internet-mediated interaction, collectively generated idea repositories, computer simulation and explicit representation of argumentation to help systematically explore, evaluate, and come to decisions concerning systemic challenges. The goal of the project is "to harness the collective intelligence of thousands of people around the world to address one of the most important problems confronting humanity today: global climate change"[96].

Within the system, users can participate in one of three activities. Firstly, users can *create plans* based on computational models of the actions humans can take, and the side effects of these actions. The side effects are predicted by a number of computational models that have already been implemented in the system. The authors are hoping to implement Internet-based models within the system in future, which can be "accessed and modified by many people" [96].

Secondly, users can participate in *debates* based around plans already entered into the system. This is achieved by entering arguments for or against the plans, or making other comments about the plans' feasibility or desirability.

Thirdly, users can *rate* the credibility of any of the plans within the system and *vote* on the plans which they feel are the most credible.

The authors hope to develop a "crowdsourced" system, that is, a system which is developed based on the needs and wants of the large user base. They predict that to be successful, the software will need hundreds of contributors in the first year, thousands in the second, and tens of thousands in the third year.

2.2.5.8 Cohere

Cohere[10] is a web-based "visual environment for making meaningful connections between ideas, and optionally tagging those ideas with websites". Ideas can be viewed as a "Connection Net" (Figure 2.13) or a "Connection List" (Figure 2.14)

The user interface allows users to search, browse, and visualise webs of ideas, problems, solutions, and arguments. Users can also add their own ideas (in the form of "idea clouds") to the map.

Although these visualisation techniques make it easier to view the relationships between arguments when there are only a small number of positions available within the system, once the number of responses reaches a high number, the graphs can quickly become overwhelmed. Cohere is intended as a knowledge mapping tool, with no conclusions being drawn from the various positions mapped out by the tool. The lack of evaluation facilities, coupled with the potential for graphs to get too complex for a human observer to draw conclusions from himself, exposes a flaw in systems such as Cohere. For graph-based systems to be implemented effectively, they should either be

[10] http://cohere.open.ac.uk/

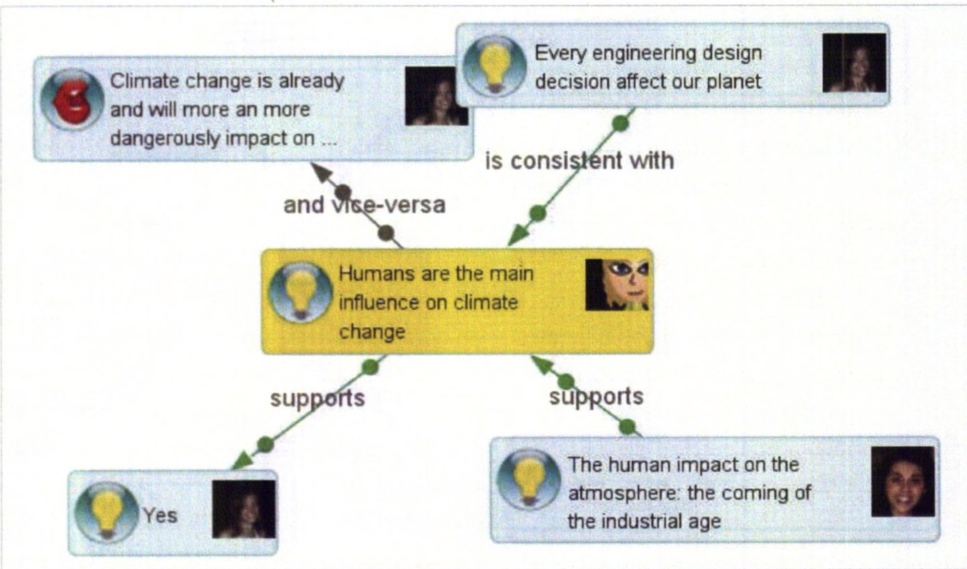


Figure 2.13: A Cohere connection net

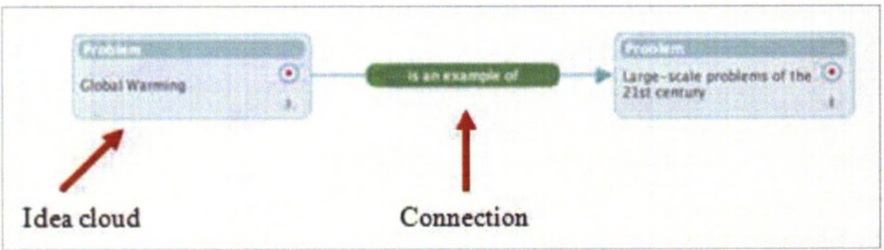


Figure 2.14: A Cohere connection list

based on a structure which permits automatic evaluation of the positions represented, or be simple enough that a user can quickly draw conclusions himself.

2.2.5.9 CoPe it!

CoPe it! [153] is a Web-based tool to support argumentative collaboration. Tools that facilitate argumentative discussion are of particular importance to CoPs (Communities of Practice). A community of practice refers to the process of social learning that occurs when people who have a common interest in some subject or problem collaborate over an extended period to share ideas, find solutions, and build innovations[11]. CoPs often deal with wicked problems, which are problems which are difficult to express, have no "correct" solution and exhibit a high degree of complexity [141].

[11] Source: http://en.wikipedia.org/wiki/Community_of_practice

The authors state that generally, systems for argumentation either provide good support for the "taming" of a wicked problem (in an attempt to harvest and justify alternatives), or they attempt to support the decision making process. CoPe it! tries to bridge this gap so that the CoP do not need to employ different tools to address both of these aspects during the same session.

The system builds on the assumption that argumentative collaboration environments are environments where understanding occurs through the emergence of the collaboration space. This emergence is characterised by small and incremental changes of the available items in the collaboration space.

CoPe it! currently supports three stages of evolution of collaboration spaces:

- **The collection and sharing stage**
  This is the most informal stage. The system functions as a web-based forum, in order to express, gather, and share knowledge items. Advanced structuring is not necessary at this point.

- **The synthesis stage**
  This stage is concerned with providing support for synthesising existing items and supporting the emergence towards coherent knowledge structures. At this stage, sense-making means achieving crystallisation of alternative solutions and explicitly representing them within the system.

- **The decision stage**
  The most formal stage of the system. It is at this stage where decision making needs are fully supported. Sense-making here means transforming the resources into a decision.

The structures created in the previous stage are transformed into IBIS-like structures according to transformation rules, which take into consideration the type of knowledge items as well as their visual attributes.

In [75], the authors discuss some evaluations of the system that have taken place in various CoPs. From 67 users who provided feedback on the tool, 66% found the tool useful and 71% found it easy to use. Despite this, 48% of users did not find it easy to understand the contents of the workspace, thus perhaps indicating some difficulties when it comes to understanding the structure employed by the system. This is of particular concern when developing argumentation support system, as it is easy for those developing such tools to incorrectly assume that the users of the software will be familiar with concepts and terminology from argumentation. Ease of use is a factor that I consider in more detail in Chapter 3, specifically with regard to how it applies in the development of tools based on argumentation for the domain of e-Democracy.

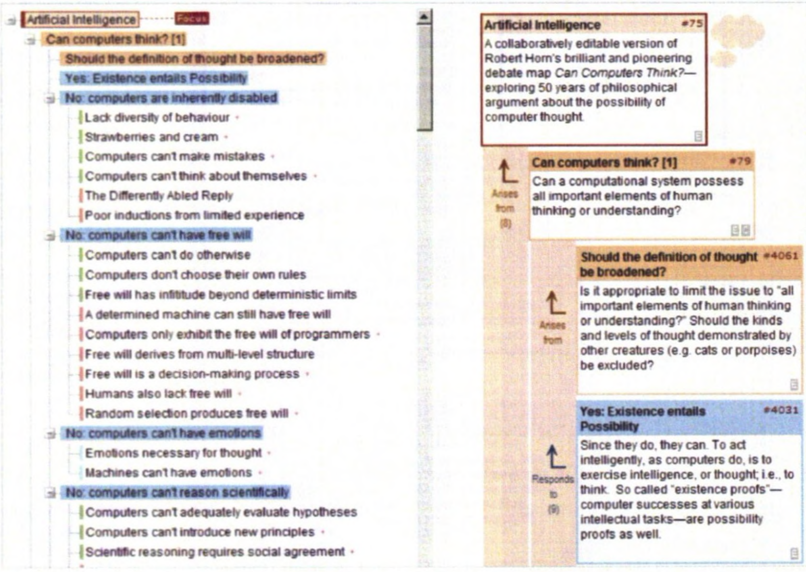


Figure 2.15: A DebateGraph debate map

2.2.5.10 DebateGraph

DebateGraph [15] (previously named DebateMapper) is a web-based tool that "allows communities of users to collaboratively model and evaluate complex debates".

DebateGraph is designed to allow protagonists for different viewpoints to collaborate in developing comprehensive debate models. This promotes greater clarity in public debates by allowing people to appreciate the strengths and weaknesses of all relevant viewpoints.

The maps within DebateGraph must conform to a map grammar. A map grammar consists of:

- A **vocabulary** of node types that may be included in a map adhering to a particular grammar
- A set of **rules** that constrain how nodes of different types may be nested in the maps tree structure. Each node type has a set of types that are allowable as child nodes.
- A set of **rules** that constrain how users may edit or otherwise interact with the map.

DebateGraph comes with a set of pre-installed grammars reflecting some commonly used formats for argument layout. This grammar is enforced as users build and edit maps, automatically disallowing nonsensical actions.

Arguments within DebateGraph take the form of an 'argument tree', in which a conclusion is supported by a tree-hierarchical serial arrangement of premises and conclusions. In addition to this, DebateGraph supports semantic cross-links, which allows items in separate maps to be connected. "Grounding" is one example of such a cross-link.

The DebateGraph system has been used to model a range of real-life issues; one example of this is its use on the website of the UK newspaper The Independent[12] in order to map issues surrounding climate change, in association with the ESSENCE 2009 project[13]. It has also been used by the U.S. Government[14].

In common with other tools which freely allow users to create arguments which go on to form a graph (e.g. Cohere, described in Section 2.2.5.8), the graph structure quickly becomes overloaded and difficult to see and understand. Despite this limitation, graph structures can provide a useful and intuitive way to present data related to arguments. In Chapter 5 and Chapter 7 of this thesis, I develop a tool which overcomes the shortfalls of tools such as DebateGraph by applying a particular theory of argumentation to the graphs created in order to effectively analyse arguments.

2.2.5.11 Debatepedia

Debatepedia[15], launched in 2006, is a free online "wiki" encyclopedia of arguments and debates. Using the Debatepedia system, users can help to construct a full picture of the pros and cons of an argument.

As a "wiki", Debatepedia allows Internet users to edit anything on the site and to help document both published arguments and original arguments.

Users can perform the following actions on Debatepedia:

- Create new debate articles in the form of "Yes/No questions"
- Write argument summaries in existing articles
- Create evidence pages for an argument, and add supporting evidence in the form of facts, quotes and links to supporting arguments
- Write and re-arrange sub-questions within debates

It is possible for a user to edit anything on Debatepedia, provided that their efforts can be "argued as improving the resource and abiding by Debatepedia editing policies and standards".

[12] http://www.independent.co.uk/environment/climate-change/mapping-the-contours-of-climate-change-1640886.html

[13] http://events.kmi.open.ac.uk/essence/

[14] http://www.whitehouse.gov/blog/Open-Government-Brainstorm-Collaboration-in-Action/

[15] http://www.debatepedia.org

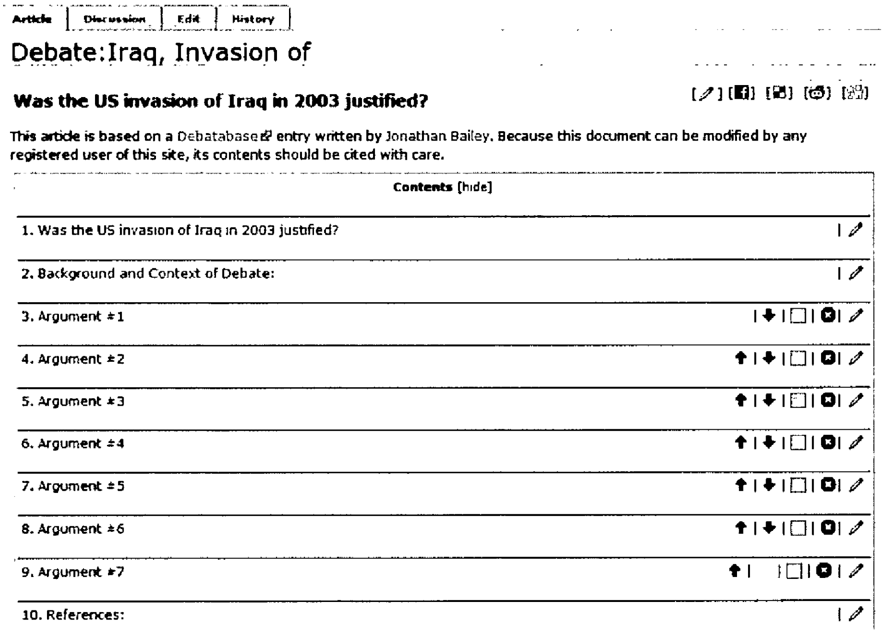


Figure 2.16: The Debatepedia website

The authors of Debatepedia propose that it has a number of advantages of paper-based reference sources; namely that articles can be improved and updated, and articles never need to be finalised. Due to the nature of the moderation on Debatepedia (i.e. users edit articles as they come across them), the authors concede that newer articles may contain little content and not conform to Debatepedia's standards as well as older articles. Another issue with Wikipedia-based websites is that, in addition to articles being "improved" by the free access typically made available to the content of the site, articles can also have negative changes made to them. In a system based around debates, this leaves the system open to possible abuse by people who may feel strongly about the topic at hand. It is not only the accidental updating of articles with inaccurate information that must be considered - some users may purposely set out to sabotage the information available on the website, and the anonymous nature of the Internet makes it difficult to prevent these attacks.

Although many online systems suffer from this problem to some degree, the nature of Wikipedia-style websites - in which the contributions of one user are freely available for modification by another - makes them particularly susceptible to these concerns surrounding security and privacy. In contrast to this, the system which I develop later in this thesis does not allow users to directly edit the arguments of others. Instead, users are permitted to critique arguments by answering a set of specially formulated questions which systematically challenge all of the constituent components.

2.2.5.12 DiaLaw

DiaLaw [87] is a framework for the domain of legal reasoning, in which legal reasoning is modeled as a two-person dialogue. The framework does not intend to model the material rules of law. Instead, a general framework is given that can be filled with specific domain rules. The framework is intended to assist in analysing legal decisions, and in constructing a rational justification for a solution to a legal conflict.

DiaLaw is an issue-based dialogue game for two players. Moves available to each player are 'claim', 'question', 'accept', 'withdraw', and 'arbiter'. The goal for each player is to convince his opponent of the correctness of the sentence he claims. Thus, it helps users to understand how to construct logical arguments against opposing claims and how to defend their own arguments.

The framework consists of dialogue moves, a commitment store, and the dialogue itself. The central notion in a dialogue is the move, in which a player performs an illocutionary act concerning some sentence. Through certain moves players become committed to sentences. Commitment restricts the moves a player can make, and commitment of players is stored in the commitment store. Dialogue is the storage of moves that each player makes, and can be represented in a tree structure.

An implementation of the model formed by the definitions and rules of DiaLaw has been implemented in Prolog. This application checks whether the input of a player is allowable. If the move is valid, the move is added to the dialogue and the commitment store is updated.

2.2.5.13 gIBIS

gIBIS [41] (graphical Issue Based Information System) was introduced in 1988 by Conklin and Begeman as a "hypertext system designed to facilitate the capture of early design deliberations". It is based on the IBIS method of argumentation, as discussed earlier in Section 2.2.1. The authors state two particular themes as guiding the design of gIBIS, the first being an interest in exploring the capture of design history (e.g. rejected options and tradeoff analysis), and the second being an interest in supporting computer mediated teamwork.

In order to develop the gIBIS tool, the authors implemented a number of extensions to the IBIS model: Firstly, the nodes and links within the model are given colours in order to distinguish the different types; a relational database is incorporated in order to support the construction and visualisation of the IBIS framework; and additional node and link types such as "Other" and "External" are introduced in order to handle exceptional cases.

The gIBIS tool provides visual presentation, manipulation and querying of the IBIS graph structure. The interface of the tool, shown in Figure 2.17, provides four tiled windows: a graphical browser (left), a structured node index (top right), a control panel

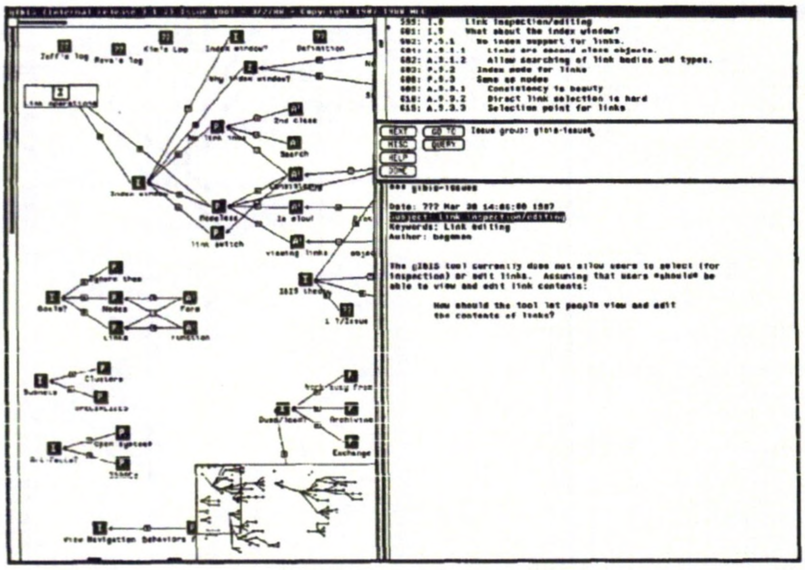


Figure 2.17: The gIBIS interface

(middle right), and an inspection window to view the attributes and contents of nodes (bottom right).

Two shortfalls of gIBIS are noted by the authors themselves. Namely that there is no specific node type for *goals* and *requirements*, and that there is no support for making decisions. gIBIS is also incapable of directly capturing group interaction (for example, in meetings), hence the development of rIBIS in [135]. The authors of rIBIS state that rIBIS has "a rich set of functionality that requires time for even experienced computer users to fully master" - thus implying that the tool requires considerably familiarisation and possibly training before users can interact with it effectively. In contrast, tools developed for e-Democracy, as investigated by this thesis, must be suitable for users to interact with casually. The system that I develop in the following chapters of this thesis hides the complex structure underlying the system in order to provide users with a simple interface, such that interactions can be fast and effective.

2.2.5.14 IACAS

IACAS (InterACtive Argumentation System) [160] is "a program written to do interactive argumentation on a computer", and was programmed using LISP. It allows a dispute to be started, given a number of facts, rules, and cases. It incorporates Chisholm's epistemological framework to interpret the outcome of the argument process. Chisholm's theory considers propositions as having one of a number of possible statuses, including; "certain", "beyond reasonable doubt", or "counterbalanced".

The authors propose that IACAS has a number of features to distinguish it from other argumentation systems:

- **Interactivity**
  The user can interact with the system in many ways, to set parameters, accommodate output, and tailor dispute records.

- **Combinatorics**
  The system finds the right arguments, and it finds them all. If one argument is defeated, the system tries the next one.

- **Epistemic status**
  The system can analyse the epistemic status of a proposition according to Chisholm's theory. Propositions can be certain, beyond reasonable doubt, some presumption in its favour, balanced, or undetermined.

IACAS uses a simple representational language in which only propositions and their negations can be represented. This language suffices to represent *rules, arguments,* and *cases*. Rules can be *strict* or *defeasible*. Strict rules represent deductive argument steps (e.g. day-is-weekday <- day-is-monday), and Defeasible rules represent plausible argument steps (e.g. white-wine <= drink-wine eat-fish).

The system was developed in the mid-1990s, and uses a command-based interface. Such interfaces are largely obsolete in modern software development, especially when considering software for e-Democracy. Although modern tools may be based on similar representational languages to IACAS, Graphical User Interfaces allow developers to abstract away from the underlying complexities of the system in order to deliver a simple interface for the end user to interact with. As the research aims of my thesis involve the development of an argumentation-based tool for use by laypersons, and hence requires a simple user interface, I do not consider any further command-based tools.

2.2.5.15 QuestMap

QuestMap [39] is a "groupware" computer-based tool for capturing and managing any size of IBIS map, and any number of interlinked maps, with a large number of users. The tool is for capturing key issues and ideas during corporate meetings. The emphasis is on improving communication during meetings by creating shared understanding. Originally used to support group facilitation/deliberation with a utilities company in California, the system supports both collaborative information management as well as group deliberation in face-to-face meetings.

QuestMap has the advantage of supporting the process, rather than just the products, of the team's work. Some other advantages of QuestMap, as stated by the authors are as follows:

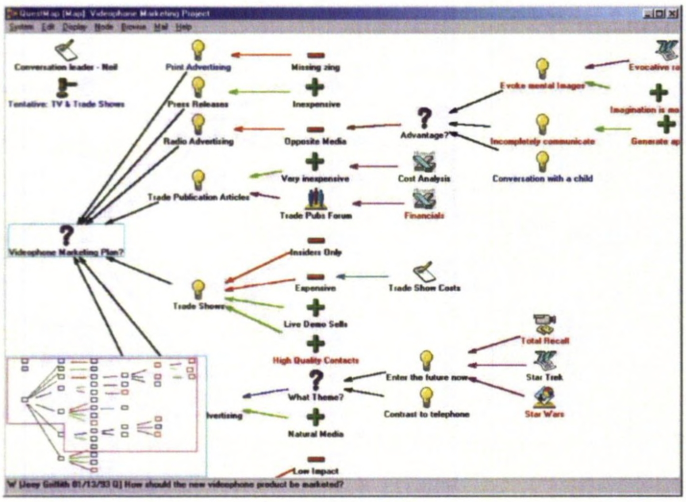


Figure 2.18: The QuestMap interface

- It allows workers to have "virtual" meetings rather than face-to-face ones.
- A complete record is available of research and rationale that leads to a decision.

QuestMap IBIS maps are created through the use of a facilitator, who is a single person nominated to transform the discussion of a group as a whole into a coherent software map, thus preventing problems which may arise if the participants were to all contribute to the construction of the map. Although this is reasonable for the purpose of small business meetings, if a large volume of participants were to be involved then the job of the facilitator would be quite difficult, as it would require him to translate the points made by the all participants into an argument graph. The use of a facilitator also restricts the meetings to one physical location, with no ability for users to participate over the Internet, for example.

Another issue with the QuestMap method of interaction is that no formal structure (and hence no formal semantics) are applied to the graphs that are created. Thus, there are no formal methods by which the data present within the graphs can be evaluated. Applying formal structures to graphical representations of argument allows them to be effectively structured and analysed according to the semantics of the formalism.

Conklin describes a case study on the use of QuestMap in [40], in which the system was used for ten years by a group of fifty users in an environmental affairs department in America. One of the main findings of this case study was that training was required in order to encourage users to participate in the system. This makes it rather unusuitable for casual users. Within the context of e-Democracy in which this thesis is set, tools must be suitable for casual users as participants are unlikely to be willing to spend a lot of time on training.

2.2.5.16 Reason!Able and Rationale

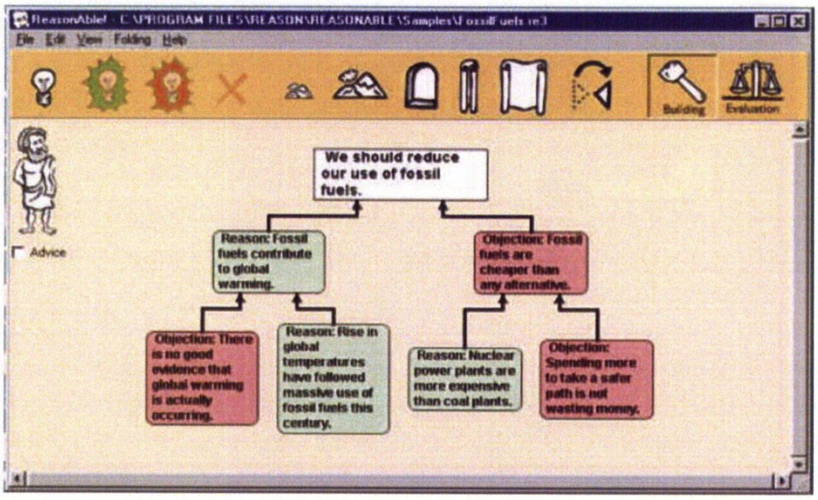


Figure 2.19: The Reason!Able user interface

Reason!Able [58] is a computer application designed to help students acquire informal reasoning skills, and is an outcome of the Reason! research project at the University of Melbourne. Rationale[16] is a commercial successor to Reason!Able.

Reason!Able allows users to represent reasoning using simple and colourful diagrams. Within the application (shown in Figure 2.19), reasons are shown in green and objections in red. The simplicity of the diagrams, which represent fairly complex reasoning, allow the user to visualise evolving arguments.

In [58], the tool was described as an "Argument Processor". It guides the user through construction and evaluation of argument trees, but does not perform any analysis of the arguments, and hence does not provide any kind of conclusion. However, as described in [56], arguments can be tagged according to a number of evaluation criteria; for example the strength of the reason/objection, degree of confidence in a claim, and independent grounds for accepting a claim as true.

The Reason!Able software was originally trialled in the teaching of critical thinking at the University of Melbourne. It has since been used in the teaching of Art, Law, Agriculture, Information Systems and Architecture. The system has also been trialled at Melbourne High School.

2.2.5.17 Risk Agoras

Risk Agoras [100] is a formal framework which can reason about scientific domains, in particular about the risk of carcinogenicity of chemicals.

[16] http://www.austhink.com/

To reason about the domain, the authors use argumentation (so that reasons for claims can be represented in association with the claims themselves) within a dialectical framework (so that cases for and against a claim can be compared). Dialectical argumentation allows the representation of uncertainty in the underlying knowledge base. In [99], McBurney defines an inquiry dialogue protocol for use in Risk Agoras.

The model on which Risk Agoras is based models a discourse between reasonable, consenting scientists, who accept or reject arguments on the basis of their relative force. Toulmin's model of argument, discussed in Section 2.1.1.1 is used within a dialectical framework to model dialogues in which the participants posit, assert, contest, justify, quantify and retract claims.

The authors anticipate the Risk Agora system being used to represent completed or on-going scientific debates, but not in real time. In contrast, the system that I develop in this thesis is intended to be a system for modeling debates in real-time, i.e. as they happen, rather than afterwards. The benefits of Risk Agoras are seen by its authors in the ability to identify gaps in knowledge and weakness of arguments, exploring the logical consequence of claims in order to make explicit knowledge, and for self-education of those outside the particular scientific community.

Although the system was not originally developed for use in the domain of e-Democracy, the authors propose that the system could be used in deliberative democracy to answer questions such as *"Should [a particular chemical] be banned?"*. This is explored further by McBurney and Parsons in [101]. Although the authors have considered the use of Risk Agoras within deliberative democracy, the application is specific to the consideration of risks surrounding the use of particular chemicals, whereas the research aims of this thesis consider the wider and more general aspect of gathering public opinion on a range of government policy proposals.

2.2.5.18 SIBYL

SIBYL [85] is a system that supports group decision making by managing aspects of the decision making process (such as the alternatives, goals, and arguments evaluating the alternatives). SIBYL can run on multiple workstations to allow cooperative, distributed decision making.

SIBYL consists of 3 parts:

- A language called DRL (Decision Representation Language) for representing the aspects of decision making. The DRL vocabulary is shown below.
- A set of services that provide qualitative decision support by using what is represented in DRL
- The user interface

DRL consists of Alternatives, which represent the options from which to choose; goals, which represent the properties that an ideal option should have. A Decision Problem represents the problem of choosing the Alternative that best satisfies the Goals. Each Alternative is related to a Goal via an "Achieves" relation: Achieves(Alternative, Goal).

The overall evaluation of a goal is represented by the plausibility of the relation, i.e. Is-the-Best-Alternative-For(Alternative, Decision Problem). An alternative is evaluated by arguing about the plausibility of the Achieves claim linking the alternatives to each of the goals, and about the importance of the goals. More generally, an argument in DRL is constructed by producing a Claim which can Support, Deny, or Presuppose other Claims.

The motivations underlying SIBYL are knowledge sharing (gathering and relating pieces of knowledge relevant to evaluating alternatives, then sharing it among participants) and qualitative decision support.

SIBYL shares with gIBIS the goal of representing knowledge that accumulates in the process of design or decision making to make it available for review or reuse. However, gIBIS lacks the notion of a goal or objective against which alternatives are evaluated (objectives are implicit). The authors of SIBYL speculate that this may explain why people have difficulty coming to a consensus by using gIBIS. This contrasts with my research, which aims to permit the gathering of public opinion on government issues including policy proposals. In this situation, the objective makes up the central part of the argument.

2.2.5.19 TruthMapping

TruthMapping[17] is a free web-based tool that provides a "focused, rational method for discussion". TruthMapping allows for the creation of Truth Maps. A Truth Map is an argument that has been broken down into its component parts (premises and conclusions), allowing for specific critiques.

The authors state that the problem with traditional methods of debate (e.g. conversation/message boards) is that the flow of information is always away from the topic. TruthMapping tries to solve this by making the topic the context which cannot be escaped and allowing revisions to statements, critiques and rebuttals. Allowing such revisions gives the user the opportunity to make his best argument in as refined a manner as possible.

The system promotes team argumentation by encouraging users to sign up friends to help them critique, evaluate, or defend a topic. It also allows users to restrict participation to a certain group of people.

In TruthMapper, users are allowed to rate critiques and rebuttals. Critiques then

[17] http://www.truthmapping.com

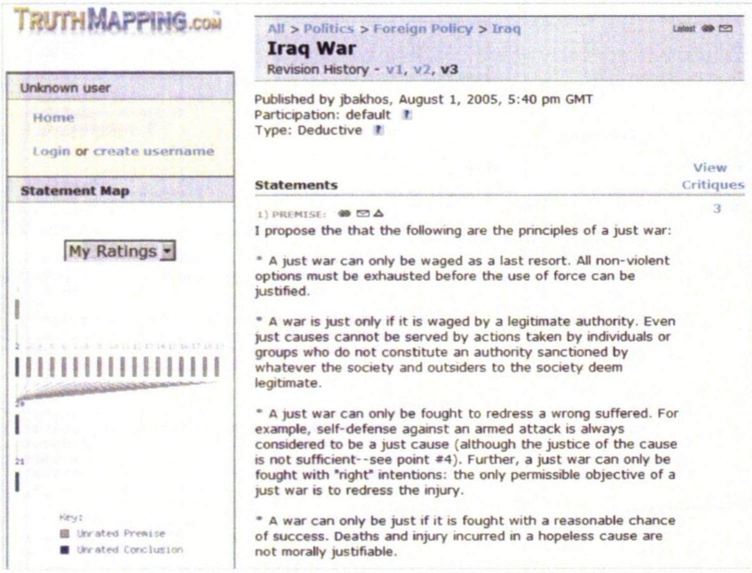


Figure 2.20: A debate on the TruthMapping website

appear after topic statements in "most agreed" order (thus giving the most relevant critique the highest placement). When expressing disagreement with an argument, the user can choose whether this is due to "generalisation", "misplaced authority", "red herring", and a number of other classifications. The exact interpretation of these methods of disagreement are left to the user, and are not associated with any particular formal model of argument.

The only method of argument evaluation within the system is in terms of the rankings over the positions of argument provided by other users. One of the main disadvantages of this is that it only takes into account the views of those who take the time to rank the argument, and the acceptability of such an analysis could be disputed.

2.2.5.20 Summary of Other Tools

A number of other tools and websites exist to support the process of argumentation. As these tools are either removed from the problem domain in which this thesis is based, or are not based on any significant model of argument, I only describe them briefly in this section.

The ConvinceMe[18] website has 3 sections named *Open*, *Battle*, and *King Of The Hill*. In Open debates, there are endless debates all competing for their side. If an argument convinces a respondent, then the creator gains a point. Battles are "one on one" debates with another member of ConvinceMe. The debate consists of a position,

[18] http://www.convinceme.net

for which one user argues against "for" and another user argues "against". The arguers can put forward positions and add evidence in order to convince other users to give the arguer their vote. The first arguer to accrue 10 points is the winner. In King Of The Hill, debates are set up based around a particular topic. Each respondent can add one position to the debate, and users can vote on which position they think is best. The first arguer to gain 5 points wins. For every debate in the system, if a user's mind is made up by one particular argument then they can add a "Convinced" vote to that argument. The author of the argument is then given 1 "Convince point", and the argument is moved up in the list of arguments. For all debates in the system, arguments are ordered by the number of people that have been convinced by the argument.

Love To Lead[19] (now discontinued) is similar to ConvinceMe, where arguments are created and users vote for or against the position presented in the argument. However, all debate topics within Love To Lead were created by administrators, and there was only one active discussion on the site at any particular moment in time. This is in contrast to ConvinceMe, where debate topics can be created on any topic by any user. Within the Love To Lead system, "bloggers" were encouraged to provide a response to the debate issue. For example, one discussion was "Is Art more valuable than Science?". Answers can be either "Yes" or "No" arguments, and respondents also provide a blog-style article to back up their selection.

Visitors to the site could vote for which argument they felt was best in responding to the discussion and also provide comments on the arguments. After the discussion has closed to new submissions, the arguments were ranked according to how many votes they obtained. For each discussion, it is also possible to see what percentage of the responding arguments are "Yes" responses and how many of them are "No" responses.

DebatePoint[20] is an online deliberation tool that can be used to "organise arguments and formalise a popular consensus over issues". The responses to each debate are organised in a tree structure, with the root of the tree being a single supporting or opposing statement for the topic at hand. Each supporting/opposing argument contributed is itself subject to further deliberation by child arguments in the same fashion. Interestingly, this system allows all registered users to moderate the arguments present within the system. Users can "support" an argument, "oppose" it, or mark it as irrelevant. The percentage of users who support each argument is shown next to the argument itself, and if an argument is marked as irrelevant by a significant number of users then it is no longer displayed.

CreateDebate[21] is defined by its authors as social decision-making software built to spur conversation and critical thinking. Each debate consists of two sides, and arguments may be added in favour of either of these sides. Arguments that are created

[19] http://www.lovetolead.info
[20] http://www.debatepoint.org
[21] http://www.createdebate.com

for each side of a debate can be voted up or down by registered members of the website, and arguments that are voted most highly are shown more prominently. These arguments can themselves be supported or disputed by further arguments put forward by other users. The CreateDebate website appears to be relatively popular, with over 10,000 active debates visible on the website, with many new debates seemingly added every day.

Room 5 [89] was a project which attempted to develop a website to provide "a mechanism for studying a broad community's willingness to perform structured legal argumentation". The research surrounding this system is considerably older than all of the web-based systems described so far in this section, with papers on the subject dating back to 1997. All of the disputes in the system were based on court cases conducted in America.

The ambitions of the Room 5 project were to:

1. Identify a community of web users willing to play semi-formal legal argument games
2. Gauge the users' willingness to be subject to constraints of various formats and gauge their understanding of constructions permitted
3. Permit a community of contributors to construct an ontology for US federal law and a database of semi-structured arguments.

The Room 5 interface used a tabular display of arguments. Claims that support a claim are enclosed within the same cell in the table. An argument and its counter-argument are displayed side-by-side. The authors claim that this tabular representation of argument avoids the "pointer spaghetti" that often results with "box-and-arrow" languages such as Toulmin's model. Where one box appears inside another box, the sentence in the first box expresses a reason for the conclusion in the second box.

The Room 5 interface allows the state of the dispute to be viewed in a number of different ways, depending on which parts of the claim should be visible. Temporary hiding of arguments and their subtrees is also possible to aid visual clarity.

When an argument is added to an existing argument, it must either support, attack, or restate the argument. When an argument is attacked, it is either attacked by giving an exception or by making a new point. The giving of an exception is the only way to defeat an argument; hence the determination of the current opinion in the argument is simple and does not require automated reasoning. If the side that is pro-petitioner can rebut all counter-arguments with exceptions, then opinion favours the petitioner, otherwise it favours the respondent.

The authors intended to impose little constraint on the text that can be entered into the system, in order to "maximise the opportunity for visitors to use the actual language of federal opinions", with active moderation being a barrier against abuse of the system.

In the late 1990s, when the Room 5 system was conceived, the use of moderation to provide an effective barrier against abuse of the system may have seemed realistic. However, the ubiquity of the Internet today means that the volume of responses to a system can quickly become overwhelming.

In this section, I have summarised a number of tools available to support the process of deliberation and debate. Most of these applications support simple argumentation online, with some method of expressing agreement and disagreement with the main topic at hand. They are not based on formal methods of argumentation, in order to encourage the participation of a large audience who would not be familiar with such formalisms.

In Chaper 3, I discuss the general advantages and disadvantages of existing tools to support the argumentation process, specifically in their application to e-Democracy.

2.3 e-Democracy

So far in this chapter I have described classical argumentation theory, the application of argumentation theory to artificial intelligence, and the development of software tools to support the argumentation process. The second research area from which this thesis draws on is that of e-Democracy (a term which is often used interchangeably with the highly related research areas of *e-Government* and *e-Participation*), and it is this research area that I consider next. e-Democracy is a combination of the words *electronic* and *democracy*, and is defined by Macintosh as "concerned with the use of information and communication technologies to engage citizens, support the democratic decision-making processes and strengthen representative democracy" [92]. Although the communication technologies that are mentioned in this definition could include interactive television and radio, telephone and other electronic methods of communication, the modern understanding of the term most often relates to the use of the Internet.

In comparison to the research into argumentation theory, described in the previous section, e-Democracy is a research area which is relatively young. Despite this, there already exists a wealth of research conferences (e.g. EDEM[22], ECEG[23], EGOV[24]) and journals (e.g. Journal of Information Technology & Politics[25]) on the topic. The research area is driven by the increasing availability of technology and Internet access to citizens, and the desire of governments to utilise such channels to reverse recent downtrends in citizen participation in government processes.

[22]http://www.donau-uni.ac.at/en/department/gpa/telematik/veranstaltungen/id/13823
[23]http://www.academic-conferences.org/eceg/eceg2010/eceg10-call-papers.htm
[24]http://www.egov-conference.org/egov-2010
[25]http://www.informaworld.com/smpp/title content=t792306880 db=all

2.3.1 Motivation

The lack of participation in democratic decision making is an ongoing concern for governments worldwide. The issue is characterised in voter turnout figures. After increasing for many decades, the average voter turnout in most democracies has been declining since the 1960s. Data made available by the UK Government[26] shows that, especially among 18-34 year olds, voter turnout has decreased sharply between the British General Election of 1970 and the election of 2001. For example, the turnout for the 1970 election was around 66.5% for 18-24 year olds, which dropped to 53% for the 2001 election. The difference was even greater in the 25-34 age group, where turnout for the 1970 election was 75.5% of the eligible population, dropping to 57.5% for the 2001 election.

Despite a wealth of scholarly research into the subject of low voter turnout, which stretches back over the past few decades, there is still some disagreement over the reasons for the decline. In [138], Riker and Ordeshook define a basic formula for determining whether an individual is likely to vote:

PB + D > C, where:

> *P* is the probability that the individual's vote will affect the outcome of the election
> *B* is the perceived benefit of the voter's favoured candidate being elected
> *D* represents the personal gratification that an individual gets from voting
> *C* is the "time, effort and financial cost" involved in voting

With regards to *D*, Riker and Ordeshook identified five major forms of gratification that people receive from voting: complying with the social obligation to vote; affirming one's allegiance to the political system; affirming a partisan preference (the act of voting for a candidate to express support, rather than to achieve an outcome); affirming one's importance to the political system; and, for citizens who find politics interesting and entertaining, researching and making a decision.

The emergence of e-Democracy provides a glimmer of hope for the improvement of voter turnout and citizen participation in democratic processes in general. I consider again the formula defined by Riker and Ordeshook, in which symbol *C* represents the "time, effort and financial cost involved in voting". It is clear to see that in a scenario in which citizens can participate in government processes over the Internet, then the value of *C* is significantly reduced, as the whole process is likely to be quicker, requiring significantly less effort and perhaps even less cost to the voter. The ability to have a say on particular issues also gives some people gratification, and hence may increase the value of *D*. *P* and *B* are also likely to be adaptable to apply to opinion gathering processes; for example *P* may be re-phrased as "the probability that the opinion cast

[26] http://www.statistics.gov.uk/STATBASE/ssdataset.asp?vlnk=5204

by the citizen will influence the decision taken by the government". The formula of Riker and Ordeshook hence provides an insight into the motivations behind citizen participation in government processes.

2.3.2 Background and History

The roots of e-Democracy date back to far before the term itself was used. In the 1960s, the National Film Board of Canada launched the *Challenge for Change* project, which aimed to "illuminate the social concerns of various communities within Canada"[27]. It gave communities access to broadcasting technology in order to enable them to record social concerns which were later shown at public meetings and to government officials. Although the project was discontinued in 1980, it provided an early insight into the power of communications technology in enhancing democracy. In the late 1960s and 1970s, the introduction of cable television brought renewed hopes for electronic participation in government processes. The term "Teledemocracy" was coined to describe the role of new communication technologies in enhancing democratic processes, and a number of experiments were set up to take advantage of the convergence between communications and television (e.g. [64], [3]). In his 1985 book *Video Democracy*, Hollander puts forward a hopeful view of the potential of new media in enhancing democracy:

> "The new technology makes direct democracy possible, indeed probable. As with all institutional change, this one will seep slowly into the system. It will not arrive with the crack of thunder or a new Constitutional Convention. The first video votes will be cast at the most local level. Even at that, the electronic plebiscites will be little more than public opinion samples. But gradually, legal authority will creep into the new system of polling. The power of law will replace the moral authority of public opinion. Politics as we know it will have been transformed. Call it video democracy." [64]

The MINERVA (Multiple Input Network for Evaluating Reactions, Votes and Attitudes) experiment of the 1970s was an "electronic technology that will allow masses of citizens to have discussions with each other, and which will enable them to reach group decisions without leaving their homes" [50]. It allowed panelists to discuss community issues, where residents could participate in the discussion from a special room equipped with conferencing equipment including a video camera. The same author later guided an experiment in which a series of sixteen telephone conference calls were carried out to explore the possibilities of extended public involvement in public decision-making. The author concludes that "a mass participatory system, based upon

[27]http://www.oise.utoronto.ca/research/edu20/moments/1966cfc.html

such electronic meetings, can be used to provide wider involvement in decision-making in our society" [136].

Other telephone-based attempts at gathering public opinion were carried out by Becker and Slaton during the 1980s. In the "Hawaii Televote" [18], random groups of citizens were contacted by telephone and asked to study a brochure containing different perspectives on a policy issue that was sent to them by mail. They were then given some time to reflect on the content of the brochure, and encouraged to deliberate with their families and neighbours on the issues presented within, before calling in to cast their vote. The "Honolulu Electronic Town Meeting", by the same authors, involved the broadcast of a number of television shows on public affairs issues with the possibility for viewers to register their opinions on the show by calling a specific telephone number during or after the show.

Many of the attempts at electronic democracy throughout the 70s and early 80s, as discussed above, combined two or more types of media in order to facilitate the delivery of information to the public, and the gathering of opinion from those who had received the information. This was due to restrictions in the communication technologies of the time - for example, information could be received using a television set, but it was not until the advent of fully interactive television a number of decades later that data could be sent using a television. Similarly, telephones were effective for gathering opinions from the public but they were not an effective method of delivering a significant quantity of high quality information.

One of the first attempts at providing a two-way interactive platform of communication was the QUBE cable television platform, introduced in Ohio in 1977. The interactive system allowed cable television subscribers to shop, bank, and complete opinion polls online. One particular example of the use of QUBE in the opinion gathering process was carried out in a suburb of Columbus, Ohio, where an "electronic town meeting" was carried out. The meeting centered around traffic and zoning problems, and subscribers to the interactive cable television service were able to participate and respond using a box of push-buttons, and the results of the polling was displayed live on the screen. Despite the effort and expense invested in this project by the company behind QUBE, including press stories and the hiring of celebrities, the response to the interactive system was not particular positive, and by 1985 the interactive facility was discontinued[28].

Some of the earliest methods of discourse over the Internet involved bulletin boards, which Internet users could use to discuss topics including those based around political subjects. The PEN project of the City of Santa Monica, America was one of the first attempts to offer citizens an electronic mail and computer conferencing system. It consisted of three components: a read-only portal which allowed citizens to access information relating to the council's agenda and how to obtain city services; a mail

[28] http://www.electrablue.com/QUBE/Electronic_Democracy.html

facility which allowed citizens to send messages to different city departments; and a conference feature which supported electronic meetings between citizens (effectively a discussion forum). The system achieved 4,500 registered users by its third anniversary, which represented about 5% of Santa Monica's residents [151, p.129]. Despite the popularity of the system in its early years, participation later began to decline with many of PEN's users preferring to use the World Wide Web as a platform for discussion and exchange (the authors of [151] speculate that this could be due to the wider range of discussion forums available on the Internet, and the visual attractiveness of websites compared to the black-and-white PEN system).

Towards the late 1990s, the Internet became a centrepiece of the future vision of digital democracy, slowly transforming it into the notion of e-Democracy that is prevalent today. The Internet now enables connectivity between billions of users worldwide, and has enhanced in functionality and interactivity since it was first available. The research presented in this thesis concentrates on the use of this widespread, highly functional method of interaction in order to provide a method of political exchange between citizens spread over a large geographical area. In the next section, I discuss in more detail the recent trends in e-Democracy and some of the prevelant ideas and research avenues within the domain.

2.3.3 Recent Trends

Today, the Internet is embraced by governments worldwide as an effective method of engaging with citizens and promoting democracy. Statistics obtained by the UK Government[29] show that 73% of households within the UK have an Internet connection (totalling 19.2 million), and 60% of adults access the Internet on a daily basis (30.1 million people). Furthermore, 97% of adults educated to degree-level have accessed the Internet at some point in their life. These figures present a significant increasing trend over the past five to ten years; in 2006, 33% of adults claimed the access the Internet on a daily basis, while in 2000, this figure was just 20%.

It is due to statistics such as these that much interest, both within government itself and the related academic research areas, has concentrated on the implementation of democratic processes on the Internet. In 2002, the UK Government published a report[30] in which they define e-Democracy as consisting of two separate areas: e-Participation, which provides "greater opportunities for consultation and dialogue between government and citizens"; and e-Voting, which considers the implementation of online voting in the UK. e-Participation is discussed further in Chapter 3 where I consider how recent research has considered methods through which citizens can share their opinions online. Although the main focus of this thesis is on gathering and analysing public

[29]http://www.statistics.gov.uk/cci/nugget.asp?id=8
[30]http://www.epractice.eu/files/media/media_619.pdf

opinion online, some of the literature on e-Voting provides a useful insight into the issues faced in providing democratic services online. For this reason, I now turn to consider e-Voting.

e-Voting (electronic voting) has been a particular area of interest both within the e-Democracy literature and within government itself. In a 2002 report commissioned by the UK Government, it is stated that "By the General Election after next - possibly as soon as 2008, certainly by 2011 - much of the ground should have been prepared for an e-enabled election, offering those who want it the opportunity to vote electronically" [31]. At the time, the rate of Internet adoption within the UK was rapidly increasing, with broadband Internet connections becoming much more commonplace. The vision of an integrated e-Voting platform at General Elections did not seem unrealistic nor bound to the future. This vision has largely failed to materialise, and in this section I consider attempts so far at implementing electronic voting both in the UK and other within other democracies, and how these attempts have been received.

It was not long after the rise of widespread access to the Internet itself that researchers began turning their thoughts to how electronic voting could be implemented within democracies, and the benefits that it would bring. A 1996 investigation by Cranor concludes that "computerised polls" could save money and enhance the privacy of citizens [43], and identifies seven characteristics which must hold for a system to be thought of as a "good electronic voting system":

- **Accuracy** - Votes can not be altered or eliminated
- **Democracy** - All of those, and only those, eligible can vote
- **Privacy** - All votes cast are anonymous
- **Verifiability** - It can be verified that the votes have been counted correctly
- **Mobility** - The system must be accessible from any location
- **Convenience**
- **Flexibility**

It is worth noting that some of these characteristics may be difficult or impossible to achieve together - for example it may be difficult to verify that votes have only been cast by those who are eligible to vote, if votes are to be truly anonymous.

I now consider some trials of e-voting that have been carried out in the United Kingdom and around the world. Although e-voting most often refers to votes being cast remotely over the Internet, it can also include votes that are cast using computer systems within the voting station itself. In May 2000, a trial of "Electronic Machine

[31] http://www.dca.gov.uk/elections/e-voting/pdf/e-summary.pdf

Voting" was carried out within three local authorities in the United Kingdom. This trial consisted of touch-screen computer systems which were installed in the polling stations of participating authorities in order to allow citizens to cast their votes electronically. As Electronic Machine Voting relies on citizens physically attending the polling station, this method of electronic voting seems unlikely to have any effect on the number of people who go to cast a vote, a fact which the government's independently commissioned report acknowledges [37]. The report does, however, suggest that the use of computer-based voting mechanisms within polling stations may help those with physical disabilities to cast secret votes.

Remote online voting, to which the term "e-voting" normally refers, is also mentioned in [37]. Although very few trials of remote electronic voting had been carried out in general elections around the world at the time that this article was published, a trial in which e-voting was used for a local referendum in three local councils is described. Within the three councils, Bristol, Croydon, and Islington, the take-up of Internet voting was 2.7%, 3.4%, and 2.4% respectively. Within the report, this low turnout is partly blamed on the "digital divide", which refers to the divide between those with access to the Internet and those who do not. At the time that this report was published (over ten years ago), the number of citizens with access to the Internet was considerably lower than it is today, so the effect of the digital divide is likely to be greatly reduced.

In 2003, a further e-voting trial was carried out in the UK. The trial involved 59 local authorities across England, encompassing around 6.4 million eligible voters - over 14% of the English electorate[32]. Later the same year, the UK Electoral Commission published a number of reports on these trials, including one report which investigated public opinion on electronic voting [38]. The findings of this report state that 57% of voters within the pilot areas were positive about e-voting, while 37% were indifferent to it. Overall, only 3% felt that the voting arrangements were "worse" after the introduction of e-voting. Considering only the 18-35 age group, a group which has a typically low turnout at general elections in the UK, 62% of respondents said that e-voting made the whole process of voting "better".

Much controversy has surrounded the e-voting pilots carried out in the UK, which includes statements by experts that the current security surrounding the systems is inadequate[33], and that they are expensive and do not increase turnout[34]. Much scholarly research has concentrated on overcoming the problems that are inherently present in any application of e-voting. Studies into methods of improving the security of electronic voting date back as far as the late 1990s, examples of which include a 1997 investigation into a secure protocol for the delivery of online voting services [72]. The development of secure and anonymous systems and protocols for electronic voting has

[32] http://aceproject.org/ace-en/focus/e-voting/countries
[33] http://news.bbc.co.uk/1/hi/uk_politics/2336023.stm, http://news.bbc.co.uk/1/hi/uk_politics/6926625.stm
[34] http://www.independent.co.uk/news/uk/politics/evoting-plans-shelved-505750.html

since been the topic of a wide selection of articles (e.g. [131], [111], [66]) and even books (e.g. [62])

Despite the obstacles preventing it from being widely introduced at the present time, some of the research carried out into e-voting gives an insight into public perception of electronic democracy in general. The feedback obtained by the Electoral Commission in relation to e-voting was positive and suggests that those involved in the pilot scheme were receptive to participating in government processes online.

Earlier in the chapter, I provided a list of seven characteristics that were necessary for a "good electronic voting system", as taken from a 1996 publication by Cranor [43]. The list comprised *Accuracy*, *Democracy*, *Privacy*, *Verifiability*, *Convenience*, *Flexibility*, and *Mobility*. Although this list was defined with electronic voting in mind, most of the points also relate to other online systems for e-Democracy, and especially systems for opinion gathering. The two processes have much in common: they are both based on processes which were traditionally paper based, with attempts being made to move them online; both attempt to promote participation by as much of the electorate as possible; and they both must attract as large a user base as possible in order to be considered representative.

By considering each of the points, one can see how they apply to opinion gathering as well as electronic voting. For example, with regard to the first point (*accuracy*), it is important that opinions submitted using online tools cannot be altered or deleted, if the system is to be a fair representation of citizen's views (although, of course, administrators may be legally obliged to remove discriminatory or defamatory remarks). *Privacy* is also of particular importance: users who submit their opinions on controversial topics may not wish for their identity to be revealed if they are to respond truthfully, and hence the degree of privacy afforded by users should be considered in the design of such systems. *Convenience*, *Flexibility*, and *Mobility* are all characteristics that are necessary in any online democratic project to be successful - and indeed it is these factors that are the main driving force behind the development of tools for e-Democracy. The issues that are prevalent in e-Voting are also a consideration in my research; for example the level of privacy and anonymity available to participants, and the security of the system as a whole.

Other authors have also attempted to identify factors that are necessary for successful e-Democracy tools and projects. One such example is provided by Bicking *et al.* in [28]. In this article, the authors describe a number of desirable features that should be present in a successful eParticipation project. Amongst the ones most relevant to the research aims of this thesis are as follows:

- *Motivation of the target users* - The authors state that this must be achieved by "active moderation" and "frequent maintenance" of the platform. In terms of a system for opinion gathering, this could involve regularly updating the system with new topics of debate and ensuring that suggestions made by users on existing debates are taken into account, with debates being updated as appropriate.

- *Use of contacts who are strongly involved in the topic* - This particular factor is rather general, but in the context of gathering public opinions on topics of debate it could relate to ensuring that the debate is constructed correctly in the first place. This may involve consulting those who are involved with, or are experts in, the particular topic.

- *Improving usability and accessibility of the platform* - Stated as requiring "proper design of the processes, technologies, and user interfaces" embodied into the platform. Web applications, especially those for e-Democracy, must be available to all citizens if they are to be truly democratic. To achieve this aim, the design of the interface must be attractive, modern, and easy to use, in addition to being accessible to disabled users.

- *Choose an interesting and important topic* - In order to ensure that citizens will proactively participate in online opinion gathering, the topics chosen must be accessible and interesting to a wide audience of all ages and backgrounds. Topics that are based around issues that are seen as boring and uninteresting are likely to give the tool a bad reputation which may be difficult to reverse.

Other critera for good design of e-Democracy systems which are not specified here could include providing good feedback to users (for example, in the form of government responses to the issues raised by respondents), and ensuring that the responses are taken into account when implementing policies (i.e. not ignoring the results). Although these requirements are rather ad-hoc and specified by individual authors, rather than being "hard-and-fast" rules, I will revisit some of them in Chapter 10 to evaluate how the system developed in the following chapters of my thesis adheres to these guidelines.

2.4 Summary and Conclusions

In this chapter, I have presented a review of some of the literature that is relevant to the work described in the following chapters of my thesis. The two main areas that I have discussed are Argumentation and e-Democracy, as these are the research areas that I draw upon in order to answer the research question defined earlier.

I began the chapter by discussing methods of structuring arguments, taken from the philosophical research area of Argumentation Theory. I then considered how more recent developments have attempted to merge argumentation theory with artificial intelligence, in order to create computational methods of representing and evaluating arguments. One of the most significant developments in this area is Dung's Argumentation Frameworks, which play a key role in the evaluative functions of the software tool that I develop in subsequent chapters. Chapter 4 extends the review of argumentation theory literature by considering the accomplishment of practical reasoning in computational systems through the use of argumentation schemes[35]. The software system that I develop later in the thesis draws upon and merges research in practical reasoning and computational models of argument.

Next, I turned to consider existing software tools developed to support the process of argumentation. I began by considering some of the literature representing significant developments within the field, which has influenced the design of the argumentation tools. I then presented a survey of 20 of the most significant software systems, in which I paid consideration to the roots of each tool, the structure on which it is based, and any documented usage which may highlight both good and bad points of the tool. Although the tools are based within different fields of implementation, many of the issues and consideration with these tools are also relevant to e-Democracy.

The final body of research which I introduced is from the area of e-Democracy. I explored the motivations for, and recent history of, e-Democracy before describing the recent trends within the field. This forms a short part of the chapter, as it is expanded in Chapter 3 where I consider in more detail the particular strand of e-Democracy on which this thesis is based.

[35]This literature is presented in a separate chapter due to its large significance to the work presented later

Chapter 3

Opinion Gathering in e-Democracy

3.1 Overview

In Chapter 2, I discussed some of the existing research in the area of e-Democracy. Despite being a relatively new area of interest, there is already a large and growing body of research, and implemented software tools, that aim to harness the ubiquity of the Internet in order to encourage the participation of citizens in government processes. In this chapter, I specifically consider methods for opinion gathering in e-Democracy, from their traditional roots to modern, computer-based methods. I then discuss the shortfalls in these computational tools, which motivates the research prescribed in Chapter 1.

3.2 Traditional Methods of Gathering Public Opinion

It is due to the very nature of truly democratic nations that the governments of such societies are interested in gathering the opinions of their citizens. Public opinion may be solicited by the government for one or more of a number of reasons; for example to gauge opinion on a current government policy, or to provide a justification for implementing a new policy. Alternatively, opinion on political topics may be solicited by bodies outside of government itself, for example to determine the most likely winner of a parliamentary election.

One of the first known attempts at political opinion polling was in the US state of Pennsylvania in 1824[1], when the *Harrisburg Pennsylvanian* newspaper surveyed local citizens on their favourite presidential candidate. The results showed Andrew Jackson leading John Quincy Adams by 335 votes to 169 in the contest for the United States

[1] http://www.fandm.edu/x3905

presidency. Other newspapers soon followed suit and also published the results of polls conducted during the same election.

Initial attempts at opinion polling were normally conducted at a local (often city-wide) level, probably due to the lack of effective and efficient methods of soliciting opinion from a wider audience during the 19th century. The manner in which such polls were conducted was relatively unscientific; for example, there was little or no attempt to ensure that the sample of people polled was representative, or that no particular bias existed in the sample [107]. Indeed, most early polling was conducted by printing ballot forms in newspapers, which respondents would simply cut out, fill in, and return to the newspaper editors. No concern was given to exactly what type of person is most likely to fill in such ballot polls, and hence there was very little consideration as to biases that may exist in those who responded.

Despite the shortfalls of early opinion polls, the sample sizes that they managed to obtain grew vastly; by 1904, the *New York Herald* newspaper was polling 30,000 electors [107], a number which was to grow higher still as the focus of opinion gathering turned towards gathering nationwide opinion, rather than just local polls. This was illustrated by the opinion polls carried out by in 1916 by the *Literary Digest* newspaper, which embarked on a national survey which correctly predicted the winner of the presidential election. The polls were conducted by mailing out millions of postcards, which respondents simply needed to fill in and return, and using which the *Literary Digest* correctly predicted the winner of the following four presidential elections. However, in the run up to the 1936 election it was revealed that although the newspaper managed to gain large sample sizes, they were all affluent Americans who tended to favour one political party. As a result, the *Literary Digest* incorrectly predicted that Franklin Roosevelt would lose the election of that year. At the same time, George Gallup[2], a pollster who had only been in business for a year, carried out a more scientific public opinion poll in which he correctly predicted Roosevelt's landslide victory.

In 1937, Gallup subsequently launched a subsidiary of his new company in the United Kingdom, named BIPO (British Institute of Public Opinion) which correctly predicted the outcome of the 1945 general election [170]. In addition to polls related to the outcome of general elections, BIPO (which later became *British Gallup*) conducted polls on a wide variety of other topics. New polls were carried out monthly until 1950, after which they were carried out on a weekly basis, always using a sample of 1,000 people. Polls conducted were based around topics such as *Do you consider that doctors should be given power to end the life of a person incurably ill?* and *Should the death penalty be abolished altogether?* A comprehensive account of all polls conducted between 1937 and 1975 is given in [54]. Many of the polls conducted by British Gallup had *Yes*, *No*, and *Don't Know* responses, often with no opportunity for respondents to give further reason for their disagreement.

[2]http://www.gallup.com

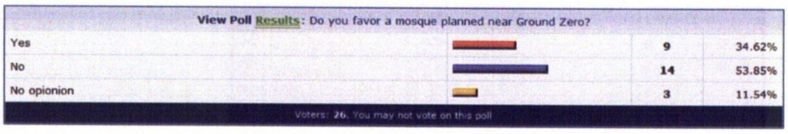


Figure 3.1: Example of an Internet-based poll

Since the introduction of Gallup polling, many other companies have been established in the UK in order to conduct opinion polling on British citizens. Among the most notable companies include ComRes[3], who conduct research for clients including the BBC and Cancer Research UK[4], and Ipsos MORI[5]. In contrast to opinion polls of the past, which were largely based on face-to-face interviews or comparatively slow postal balloting, opinion polling of today is often conducted using new, electronic media. For example, Ipsos MORI use telephone surveys which are based on random digit dialing in order to obtain a random sample of respondents.

The use of opinion polling has spread rapidly since the middle of the 20th century, and is now used in most democracies throughout the world. As new, widespread communication technologies have developed, the methods of gathering public opinion have also adapted and evolved to take advantage of these technologies. In the next section, I discuss how computers and the power of the Internet has been harnessed in order to support the process of opinion gathering and deliberation based on the resulting data.

3.3 Computational Methods of Gathering Public Opinion

The advent of the Internet and enhancement in computing technologies has allowed governments (and other bodies) to take advantage of the ubiquity and efficiency of these new technologies in order to gather the opinion of citizens. Internet-based opinion polls appear in many forms; for example as a "widget" on a webpage, or to accompany a discussion on Internet-based discussion forums (a current example is presented in Figure 3.1, which centres around the construction of a mosque in New York).

Internet-based polls, whether set up by governing bodies in order to determine the opinion of citizens, or casual polls set up by Internet users to canvas the opinion of peers, carry a number of advantages over more traditional methods of polling. In [24], these advantages are stated as *low cost per completed response*, *capability of providing respondents with a large amount of information*, *speed* and *elimination of interviewer bias*. Internet-based opinion gathering allows for citizens to participate in their own

[3]http://www.comres.co.uk
[4]http://www.comres.co.uk/our_clients.aspx
[5]http://www.ipsos-mori.com/

time, with the resulting data being made available to interested parties almost as soon as it is submitted.

One of the most recent examples of opinion gathering over the Internet was for the United Kingdom general election of 2010. During the election campaign, the leaders of the three main political parties appeared on television in a number of live televised debates. During one such televised debate, broadcaster ITV[6] ran a poll on its website in order to track public response to the broadcast in real time. The 23 million UK users of the Facebook social networking website were able to participate in the poll through the Facebook website itself[7]. The results of the live Internet polling, gathered through the ITV website and other websites such as Facebook, were overlayed on the live television (and Internet) stream of the debate.

Other methods of indirect opinion gathering were used during the same election debate; for example, the analysis of messages posted to the Twitter social networking website[8]. The use of social networking to gauge public opinion is described further in Section 3.3.1.3.

Based on the discussion so far, the use of the Internet in the gathering of public opinion seems to be both beneficial for bodies looking to obtain information regarding public opinion, and engaging for those participating. Throughout the remainder of this section, I discuss some of the most significant developments in the domain of computational opinion gathering tools over the past few years.

Although much of the discussion so far in this section has concentrated merely on the act of gathering public opinion, another important aspect in the process is that of trying to draw conclusions from the data provided. I recall one of the definitions of *argumentation*, which was given in Section 2.1:

> "The principled interaction of different, potentially conflicting arguments to obtain a consistent conclusion"

It is evident from this definition that the act of government deliberation with regard to public opinion can be thought of as a product of an argumentation process. It requires analysis of the range of opinions submitted (the "different, potentially conflicting arguments"), in order to be able to determine the standpoints which are most popular amongst the population ("consistent conclusions").

The discussion comprising the rest of this section is split into two sections; Section 3.3.1 introduces tools which can be defined as "informal" opinion gathering and sharing tools and methods, which are not based on any formal underlying structures and often rely on users themselves to construct and organise their position. In contrast, the tools described in Section 3.3.2 are based on formal models of argument, thus providing a structure to the positions of respondents and the relationships between these positions.

[6]http://www.itv.co.uk
[7]http://www.netimperative.com/news/2010/april/itv-election-debate-facebook-2018dial-test2019-to
[8]http://linguamatics.wordpress.com/2010/04/16/first-debate/

A critical review of these tools and the categories that they fall in to is provided in Section 3.4, as part of a wider investigation of the general issues inherent to current tools for e-Democracy.

3.3.1 Systems Based on Free Argument

In this section, I discuss some existing computational methods of opinion solicitation and analysis which are not based on formal models of argument. Such systems normally encourage participation by being easy to use, often allowing users to be expressive in their interaction with the system. They typically rely on users themselves to structure their arguments and any linkage between their argument and other relevant arguments (possibly other arguments within the system, or within the world as a whole).

I now discuss some of the most interesting and relevant systems that falls into this category, starting with e-Petitions.

3.3.1.1 e-Petitions

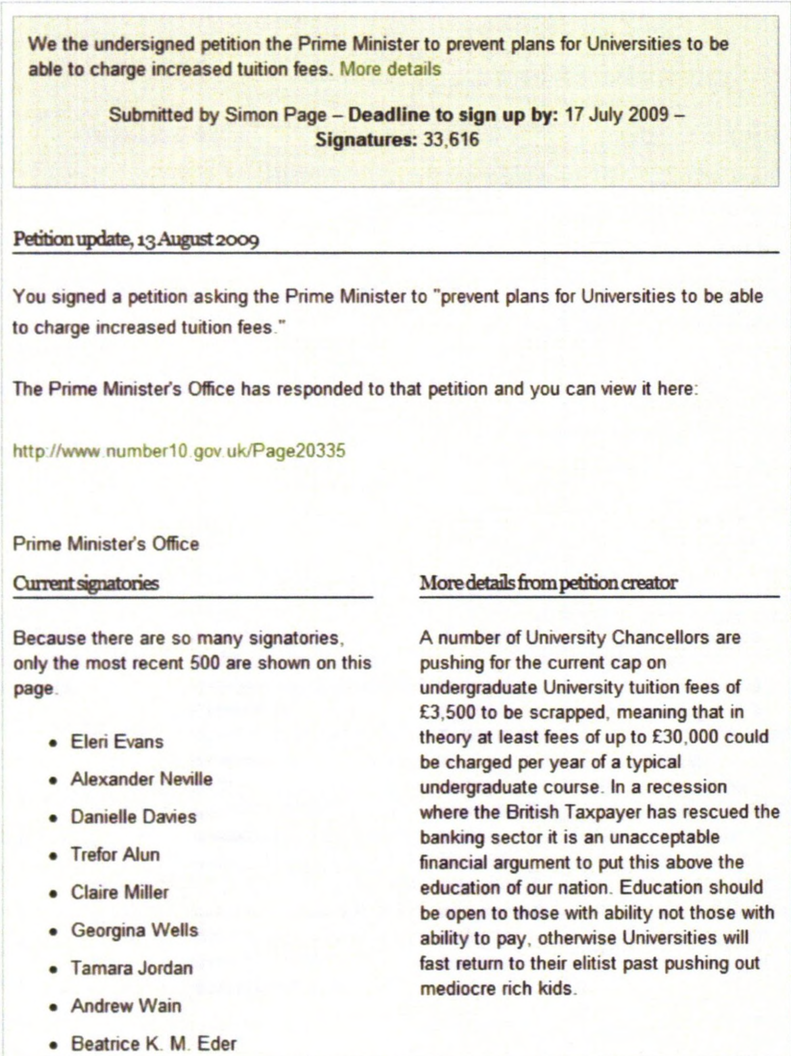
Recently, e-Petitions have become a popular mechanism for gathering public opinion on topics suggested by members of the public. Their popularity could be attributed to the wide reaching nature of the Internet, which allows a large volume of people across geographical boundaries to access and electronically "sign" the petition. This is in contrast to paper-based petitions, where obtaining signatures is a labour intensive task, and often only possible within small geographical boundaries. e-Petitions are also significantly cheaper than their paper-based counterparts, as signatures are solicited electronically over the Internet at no cost to either the creator of the petition or the person signing it. This is in contrast to traditional petitions, where the petition creator will often have to travel in order to solicit responses from the public, or signatories have to travel in order to add their signature to the petition.

Although an e-Petition could theoretically be created for presentation to any person or group, the main area of interest appears to be in creating petitions for presentation to government. One such example is the UK Government e-Petition website[9], which has been running since November 2006. This site enables users to create, view and sign petitions. The motivation behind the use of such petitions is stated on the website as making it "easy to collect signatures, and it also makes it easier for us to respond directly using email".

Once a petition has closed, the names and email addresses of all those who signed the petition is forwarded to the government. The government then responds to the petition by sending an email, addressing the points raised in the petition, to all those

[9]The UK Government e-Petition website: http://petitions.number10.gov.uk

who signed it. The e-Petitions website has proved popular, with one particular petition having gained over 1.81 million electronic signatures[10].


We the undersigned petition the Prime Minister to prevent plans for Universities to be able to charge increased tuition fees. More details

Submitted by Simon Page – **Deadline to sign up by:** 17 July 2009 – **Signatures:** 33,616

Petition update, 13 August 2009

You signed a petition asking the Prime Minister to "prevent plans for Universities to be able to charge increased tuition fees."

The Prime Minister's Office has responded to that petition and you can view it here:

http://www.number10.gov.uk/Page20335

Prime Minister's Office

Current signatories

Because there are so many signatories, only the most recent 500 are shown on this page.

- Eleri Evans
- Alexander Neville
- Danielle Davies
- Trefor Alun
- Claire Miller
- Georgina Wells
- Tamara Jordan
- Andrew Wain
- Beatrice K. M. Eder

More details from petition creator

A number of University Chancellors are pushing for the current cap on undergraduate University tuition fees of £3,500 to be scrapped, meaning that in theory at least fees of up to £30,000 could be charged per year of a typical undergraduate course. In a recession where the British Taxpayer has rescued the banking sector it is an unacceptable financial argument to put this above the education of our nation. Education should be open to those with ability not those with ability to pay, otherwise Universities will fast return to their elitist past pushing out mediocre rich kids.

Figure 3.2: Example of a petition from the e-Petitions website

Figure 3.2 shows an example of a petition from the e-Petitions website. This particular petition proposes that plans for universities to be able to charge increased tuition fees are scrapped. A justification for this action is also given, along with the names of all those who have given their support to the petition.

e-Petitions have a number of limitations; firstly, there is no facility to visually anal-

[10]http://petitions.number10.gov.uk/traveltax/

yse or evaluate the positions of different participants in the debate; secondly, it is not possible to tell how many people disagree with the petition, since there is no option to state disagreement; and thirdly, of those who do agree with the petition, it is not possible to see exactly *why* they agree. Some of these issues are inherent to methods of opinion solicitation which are based on "free argument" (i.e. have no underlying structure). Such issues are discussed further in Section 3.4.1.

3.3.1.2 Highland Youth Voice and Ur'Say

Highland Youth Voice and Ur'Say are both systems developed for e-Democracy by Ann Macintosh and colleagues [94]. They were developed in the early 2000s, an era in which declining participation of young people in traditional democratic processes coincided with rapidly increasing availability of always-on Internet connections in homes and schools.

The work of Macintosh *et al.* focussed on the development of two particular systems for assisting the participation of young people in democratic processes over the Internet. The first software system, named *Highland Youth Voice,* is designed to encourage the young people living in the Scottish Highlands to participate in democratic decision making that is related to their lives. The system is designed to engage those aged 14-18 in democratic processes. Members of Highland Youth Voice are elected to an assembly through schools and youth forums by other young people of high school age.

The website enables members of Highland Youth Voice to participate in activities related to the assembly over the Internet. Three particular types of activity are described by Macintosh; *communication* about the activities of the project, *discussion* about the issues affecting young people in the area and *online elections* of new members to the assembly. The discussion aspect of the system, which forms an "online policy debating forum" [94] is of particular relevance to the research aims of this thesis.

The forum allows users to log in using a User ID and Password which are distributed through schools and youth clubs. Although all posts within the forum are visible to the public, only those who log in using a valid User ID can post new topics or reply to existing ones. The topics of debate arise either from face-to-face meetings of the assembly, or from local and national public bodies. Two expert witnesses take part in each online debate in order to provide extra information where required.

Once the debate has closed, feedback is provided on the website as to the outcome of the debate; for example, who users' contributions have been passed on to, and any resulting action that has been taken.

The second system described in [94] is *Ur'Say*, which is a constituent part of the YoungScot information portal for young people[11]. Ur'Say is described by the authors

[11] http://www.youngscot.org/

as "a members' discussion forum, designed to engage a wide range of young people with contemporary issues". All "e-consultations" within the Ur'Say forum contain an introduction, which provides information on the consultation and its possible outcomes; a "behind the scenes" briefing, which outlines the key choices, questions, and dilemas which surround the particular debate; and statements from an "expert panel", consisting of key organizations who are dealing with the real world issues surrounding the discussion.

Once the debate has closed, then it is the responsibility of the moderator to summarise the discussion in a consultation report which is delivered to the appropriate voluntary or public body.

3.3.1.3 Interactive Websites, Blogs, and Social Networking

So far in this section, I have discussed tools which were created specifically for the purpose of soliciting the opinions of the public on particular topics. However, the ubiquity of the Internet has led to users voluntarily sharing their opinions on many aspects of their lives, through interactive websites, blogs, and social networking websites.

Social networking sites such as Facebook and Twitter allow their users, which total over 400 million[12] in the case of Facebook, to broadcast their opinion to others within their social network. Web logs ("blogs") are another popular medium for the public to express their opinions on various topics. Both of these mediums allow interactive expression of opinions, where one person is able to put his opinion forward and another can respond to this opinion.

Bodies who wish to gauge public opinion often solicit such information through social networking websites in a number of ways. Comments shared through the Twitter website can be analysed using natural language processing tools in order to determine users' thoughts on a particular topic ([70] and [114] are examples of research in this area). A recent study by the Carnegie Mellon University of Pittsburgh found that computational analysis of 1 billion Twitter sentiments yielded similar results to opinions gathered using well-established traditional polling methods (including those conducted by the Gallup company, as described in Section 3.2) [114]. The authors promote the use of Twitter analysis over traditional polling methods as it is less time-consuming and costs less to operate. The authors conclude that advances in the way that the messages are analysed, as well as advances in the research field of Natural Language Processing itself, could lead to more consistent results.

Although the Facebook social networking website also provides methods for users to share their thoughts and opinions, the privacy settings that are intrinsic to the Facebook model often prevent these messages from being widely available, and hence it remains difficult to harvest opinion.

[12] Source: http://www.facebook.com/press/info.php?statistics

In an attempt to promote interactivity, news websites often allow users to submit their opinion on news stories that they publish. One example of this is the BBC News "Have Your Say" feature[13], through which users can submit a comment on a particular news story, or a topic of debate, which is then considered by an administrator and printed on the discussion forum if selected. In contrast to discussion forums such as Ur'Say, described earlier, there is no attempt made by the moderators to summarise a discussion once it has closed. Rather, entries remain available for users of the website to view and draw their own conclusions.

The popularity of web logging ("blogging") makes it another good source of user opinion. Users typically make posts about topics relevant to their lives, or perhaps the particular topic on which their blog is based, which can consist of as many or few words as the author desires. Other users can then make comments reflecting their own thoughts and opinions on each blog post. Discussion forums themselves provide a similar domain in which users express their opinions on a huge variety of different topics, using as many words as they desire and perhaps including other multimedia features such as images and videos. Some research exists on the topic of using text mining in an attempt to gauge public opinion from online blogs (often termed "opinion mining", which I briefly discuss in Section 3.4.1.1) ([154], [14], [82] present attempts at opinion mining from blogs).

3.3.1.4 YouGov

YouGov[14], launched in 2000, is an online polling service based in the United Kingdom. It was the first agency to conduct opinion polls which were representative of the nation wholly online. The ambition of the YouGov service is to "supply a live stream of continuous, accurate data and insight into what people are thinking and doing all over the world, all of the time".

Many of the existing methods of online polling, including the e-Petitions described in Section 3.3.1.1, use *passive sampling* of respondents. This means that anyone can participate in the poll, often more than once if they so desire. In contrast, YouGov uses *active sampling* for its surveys. This means that only respondents specifically invited to take part in a particular survey can do so, using a unique username and password which is assigned to users when they subscribe. YouGov select participants in each particular survey from their 280,000 member base.

When a person signs up to be a part of the YouGov Panel, he or she is asked to respond to a number of demographic questions (including age, gender, and newspaper readership). It is from this demographic information that those invited to participate in each survey are chosen, and each chosen person who does respond to the survey is offered a small monetary incentive for doing so. The panel-based approach of the

[13] http://news.bbc.co.uk/1/hi/talking_point/default.stm
[14] http://www.yougov.co.uk/

YouGov allows users to be carefully selected in order to obtain a representative sample of the population. In addition to the sample selection process, YouGov also applies a weighting to the collected responses based upon the demographic profile of each user. However, the offering of a monetary incentive could be seen as possibly affecting the response given by users, who may feel that they need to give a particular response in order to be selected for future survey panels (and thus receive more money).

One of the major sources of YouGov panel members during the early years of its existence was through their partnership with Freeserve, the first subscription-free ("Pay As You Go"), and hence highly popular, Internet service provider in the UK. Some of the content of the Freeserve web portal was sourced from YouGov, and in order to interact with this content, users needed to sign up to be a panel member of YouGov. Soon after its launch, the general election of 2001 allowed YouGov to prove their effectiveness, their prediction comparing very favourably to the actual result and correlating with the predictions of other major pollsters. YouGov have accurately predicted the outcome of several elections since this time, including British General Elections [152].

Having briefly outlined some of the interactive and social networking websites that citizens often use to express their thoughts and opinions, I now go on to consider tools which are based on formal structures of argument, informed by scholarly research within the domain of argumentation theory. I return to discuss unstructured tools and some of their inherent issues in Section 3.4.1.

3.3.2 Tools Based on Structured Argument

In this section, I consider tools that are based on formal underlying models of argument. This formal basis often means that the positions represented within the tool must be structured according to the particular model on which the system is based. These structured tools often support more of the discourse process, including the structuring of arguments and positions, and the evaluation of such positions in order to determine which are acceptable. In contrast, the unstructured tools in the previous section grant much more freedom to users, but do not provide the structure and semantics that are necessary for evaluation of the arguments. Structured tools are typically influenced by more general computational tools developed to provide support for decision making, as described in Section 2.2. Some of these tools were based on formal theories of argument to allow for effective structure and analysis of the arguments represented within the tool.

3.3.2.1 Zeno

The Zeno Argument Framework [60] is a formal model of argumentation, designed for use in mediation systems (an electronic discussion forum with special support for argumentation, negotiation, and other structured forms of decision making). A mediation

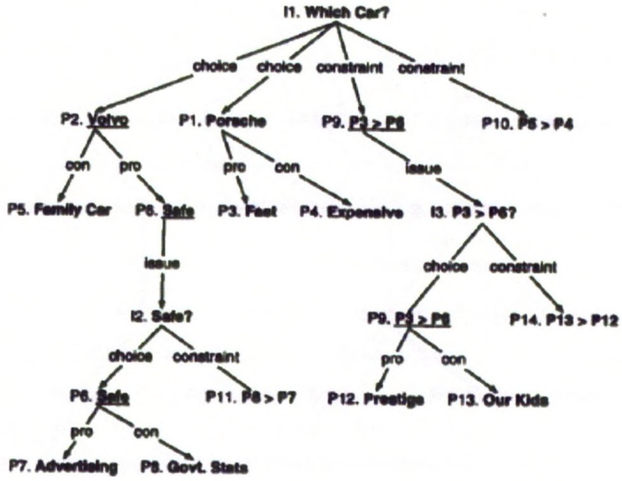


Figure 3.3: A Zeno Dialectical Graph

system should make it easy to quickly obtain an overview of the state of a debate (i.e. the arguments in the system and the relationships between them).

Zeno is open source, and written in Java. More recently, a commercial version of Zeno has been released, named Dito and marketed by Ontopica[15].

Figure 3.3 shows an example of a Zeno Dialectical Graph. The Zeno system was originally based on the IBIS model of argumentation (see Section 2.2.1), although later versions of the tool allowed moderators to configure the model. Despite the lack of formal semantics in IBIS, the authors of Zeno note that it is useful for structuring and organising information. IBIS includes "pro" and "con" arguments, but these have no effect on the status of positions within the model. Zeno overcomes this limitation with a means to express preferences and compute position labels. Zeno also allows users to qualify positions, a significant advance over the IBIS model by allowing parties to see whether their positions are "winning" and "losing", given arguments made so far, perhaps encouraging them to submit better arguments in favour of their positions.

Zeno has been used in a number of e-Democracy pilot applications, the earliest of which is the GeoMed project (Graphical Mediation System). GeoMed aimed to involve citizens in regional and urban planning, and "supports spatial planning and decision making by an integrated concept of shared workspace, Internet mapping and discussion forum" [145]. Within GeoMed, Zeno was integrated with a Geographical Information System in order to enable citizens to discuss city plans over the Internet. Zeno has since been used in a number of other planning consultation systems, including CommonGIS [159] and in the German city of Esslingen as part of the Media@Komm

[15] Ontopica: http://www.ontopica.de

project [109].

The Esslingen project identified three particular areas in which the Zeno process had an advantage over offline consultations; firstly, information can be made more accessible to the public, reducing the imbalance between the information available to citizens and information available to planning officials; secondly, computer-based documentation automatically leads to an archived record of the whole process; and thirdly, interactive communication in which citizens can see the opinions of others, and multiple issues can be discussed thoroughly in parallel, in comparison to offline communication in which citizens are often isolated from the views of other citizens [109].

A disadvantage identified with the Zeno system is the fact that a moderator is required to read through all of the contributions to ensure that they are appropriate and placed correctly. This is likely to be time consuming and expensive in a situation in which the system is used by a large number of citizens. The issue of moderation is considered further in Section 3.4.2.

One of the major implementations of Zeno has been in the form of the DEMOS system, a tool developed to enhance citizen participation online. It is this tool that I describe next.

3.3.2.2 DEMOS

DEMOS (Delphi Mediation Online System) [91] is a tool intended to support e-democracy online, to "enhance citizen participation in modern societies". Some elements of the system are based on Zeno, described earlier.

The DEMOS project is based on assembly and integration of three well-understood social research methods:

- **The Survey Technique** - This method is designed for representative polls, and contributes to public opinion formation on a large-scale basis including a large majority of the entire population. From this, DEMOS takes the idea of mass opinion polls on a large scale basis.

- **Delphi Polls** - Operate with a certain amount of interactive feedback, but have limited scalability. Delphi polls can be used in DEMOS to exploit expert knowledge, by generating a consensus among a limited number of domain experts by aggregated feedback.

- **The Mediation Technique** - A qualitative method used to reveal problems and resolve conflict. Mediation is a group process, with limited participants, that runs through several cycles of open discussion. DEMOS takes the idea of an open process of participative conflict resolution.

These three methods are applied and merged together in the "DEMOS process" (which is concerned with one main topic to be discussed on a limited timeline under the guidance of moderators). The first phase is the "broadening of the discussion", in which moderators analyse free-text contributions to the system in order to determine "the most important aspects or subtopics of the chosen subject matter". In order to achieve this, the moderators must analyse and cluster free text contributions to come up with a list of sub-topics which most of the participants seem to be interested in. The result of the first phase is a set of discussion forums which are set up to discuss the identified list of interesting topics in more detail.

The second phase ("deepening of the discussion") consists of more in-depth discussions in each of the sub-forums created as part of the first phase. Once these discussions have finished, the moderator must create a summary of the topics discussed in the forum during this phase. The third phase is termed "consolidating the discussion" and involves transferring back the summary of sub-forum discussions to the main forum. Throughout the phases, users are given the opportunity to complete surveys in order to gauge opinion on the way the discussion is progressing and to give participants the opportunity to shape the future discussion.

The main element of DEMOS is the forum, where topics are discussed under guidance of a moderator. Support for some issue-based elements of the forum is provided by the Zeno System. The integration of the various elements of the DEMOS system is shown in Figure 3.4.

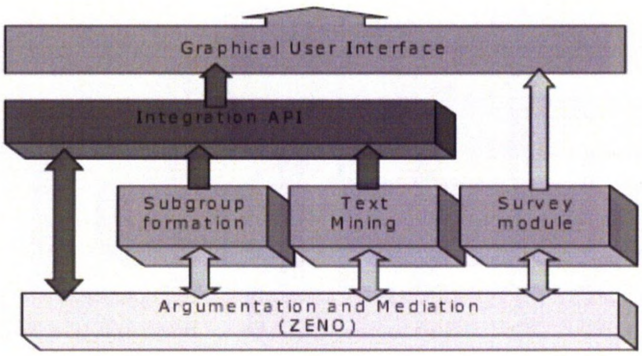


Figure 3.4: DEMOS system modules [91]

3.3.2.3 HERMES

HERMES [74] is a Collaborative Decision Support System, which are defined in [81] as "interactive computer-based systems, which facilitate the solution of ill-structured problems by a set of decision makers working together as a team". We can see how this definition holds in the domain of e-Democracy, with the "ill-structured problem" being the issue put forward by the government and the "set of decision makers" being the citizens who collaborate to reach a conclusion. Much like DEMOS, described above, HERMES is also based on the Zeno system described in Section 3.3.2.1. The system allows for distributed, asynchronous collaboration, allowing users to surpass the requirements of being in the same place at the same time.

The HERMES system improves on threaded discussion forums by helping decision makers to reach a decision by structuring the discussion and providing reasoning mechanisms for it. The primary goal of the system is to develop a "generic active system that efficiently captures users' rationale, stimulates knowledge elicitation and argumentation, whilst constantly automatically checking for inconsistency among user preferences".

The authors argue that the majority of existing collaborative argumentation support systems were designed to support face-to-face meetings with a human facilitator, whereas it is actually virtual support that is needed for government-to-government collaboration. To this end, HERMES is intended to act as an *assistant* and *advisor* to debate, by facilitating and recommending solutions, but leaving final enforcement of decisions and actions to the user.

HERMES has the following argumentation elements:

- **Issues and Alternatives** - Correspond to decisions to be made or goals to be achieved. Consist of a set of alternatives that correspond to potential choices.
- **Positions** - These are asserted in order to support selection of a specific course of action, or avert the users' interest from it by expressing an objection
- **Constraints** - Provide a qualitative way to weigh reasons for and against the selection of a certain course of action.

A real-life application of the HERMES system is described in [73], in which the system was used to structure a debate on whether non-state funded universities should be allowed in Greece. Four groups of users participated in the debate, each representing a stakeholder in the issue. All of the participants were familiar with using computers, the Internet, and electronic forums; and all were given additional training on how to use the system before the discussion began.

The results of this evaluation showed that most users felt that the system stimulated discussion, was easy and enjoyable to use, and that they would be prepared to use it again. Some users found that the system was not easy to learn. The authors also state that some users had difficulties in understanding the argumentation content of the system, as well as understanding exactly what they had done at each stage and what they had to do next.

3.3.2.4 Compendium

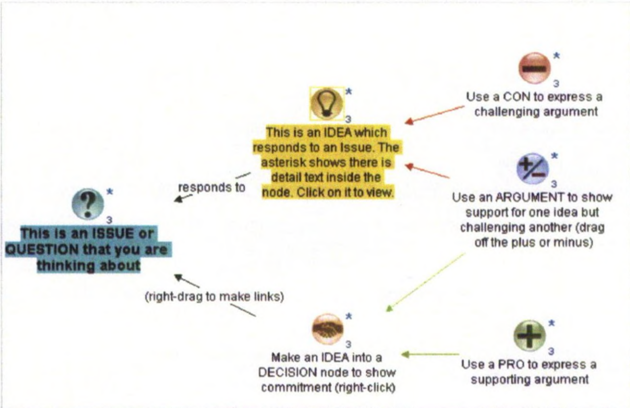


Figure 3.5: A Compendium argument map

The Compendium tool [42] supports real-time argument visualisation in meeting rooms. It is the successor to QuestMap and is based on the same issue-based information system for structuring the discussions that take place. One of the improvements of Compendium is that it gives more rapid benefits rather than the long-term ones offered by the QuestMap tool.

A session mediated by Compendium takes place in a room with a projector screen, and has 3 elements:

1. **Graphical hypertext system** - A visual map of Questions and Ideas is built for all to see and react to. Discussion becomes mediates by this map.

2. **Facilitator** - Actively works with the group, forming a bridge between their conversations and the Compendium representation

3. **Conceptual frameworks** - Structure the knowledge and shape group's process, and determine what kind of questions and ideas are asked. The frameworks can be broken out of, to allow more "ad-hoc" discussions.

The Compendium approach was used widely on over 60 projects between 1991 and 2001. More recently, the use of the tool in an e-Democracy setting has been illustrated by Renton and Macintosh in [137]. In this paper, the authors investigate to what extent computer supported argument visualisation can encourage debate and deliberation by citizens on public issues. Specifically, the paper considers the ban on smoking in public places that was introduced in Scotland in 2004. Argument maps are created to allow those affected by the ban to see the different points of view proposed by different parties, and provide links to any supporting documents that are cited by these parties.

Another example of the use of Compendium in an e-Democracy setting is in [115], where Ohl models the results of a consultation with citizens in the form of a Compendium argument map.

3.4 Issues in Current Computational Tools

In this section, I consider again the tools described in the previous section and examine some of their inherent issues. These issues motivate the requirement for some of the research described throughout the rest of this thesis.

3.4.1 Unstructured Tools vs. Structured Tools

The first issue that I discuss, which is a major issue in the design of systems for e-Democracy, is the trade-off between structure and ease of use. On the one hand, we have systems that are easy to use and encourage participation by allowing users to be as expressive (or unexpressive) as they desire. Such systems may allow users to enter their position in free text format without any consideration as to the underlying argument structure. However, such tools are typically unstructured and thus analysis of data collected using these systems is often problematic. In contrast to this, we have systems that are underpinned by highly structured formal structures, but require users to have a deep understanding of the underlying structure before they can use it effectively. Thus, such systems are often seen as too difficult to use by laypersons. In an e-Democracy context, in which it is desirable to encourage the participation of as much of the public as possible, ease of use is one of the main considerations.

I now articulate the discussion by considering unstructured and structured tools in turn, using examples from the previous section to illustrate some of the shortfalls in tools from each category.

3.4.1.1 Unstructured Tools

I begin this section by discussing e-Petitions, which I introduced in Section 3.3.1.1, to provide a specific example of a problem encountered with many unstructured systems. Recall from the earlier discussion of e-Petitions, that they facilitate signature collection and also provide a means by which the government can respond to all those who have expressed agreement with the issues raised by the questionnaire via email. They are also simple to use, as illustrated by the large amount of digital signatures accrued by some petitions. Despite these obvious advantages, the quality of engagement is questionable due the problems suffered by this method of communication. Firstly, e-Petitions as used here are simply electronic versions of paper petitions. Whilst making petitions electronic may increase their visibility by exploiting current favoured methods of communication, they still suffer from the same shortcomings as paper versions. The most significant of these is conflation of a number of issues into one stock statement.

To illustrate this issue I first consider the following e-Petition, taken from the e-Petitions website, which proposes to "repeal the Hunting Act 2004":

> Petitioners know that The Hunting Act 2004: has done nothing for animal welfare; threatens livelihoods in the longer term; ignores the findings of Lord Burn's Enquiry; gives succour to animal rights extremists; is based on political expedience following the Prime Minister's unconsidered response on the television programme Question Time in 1999; is framed to persecute a large minority who support a traditional activity; does not command popular support in the country except amongst the uninformed and mal-advised.

By the deadline for the closure of the petition (November 2007) it had attracted 43,867 signatures. Once such a petition is closed it is then passed on to the relevant officials or government department for them to provide a response. The website states that "Every person who signs such a petition will receive an email detailing the government's response to the issues raised". However, it is questionable as to whether such a stock response can appropriately address the precise concerns that the signatories have with the issue. This is because the issue stated within the petition covers numerous different points and motives for disagreement, whilst those signing the petition will have more particular concerns. If we consider the example petition given above, we can see that the repeal is justified based on numerous different arguments:

- disputed facts, e.g. (i) that the Act ignores the findings of The Burns Enquiry (which, prior to the Act, investigated the impact of fox hunting and the consequences of a ban); and (ii) that public support for the Act is low;
- the bad consequences that have followed from implementation of the Act, e.g. (i) that there is an absence of improvement in animal welfare; (ii) that the Act supports the activities of animal rights extremists; and (iii) that the Act poses a long term threat against livelihoods;
- the misaligned purposes that the Act promotes, e.g. (i) the unjustified persecution of those who support hunting with dogs; and (ii) the political gain of the Prime Minister following the introduction of the Act.

So, in signing the above e-Petition it can only be assumed that the signatory agrees wholeheartedly with *all* of the objections raised in the statement. This makes it easy to oversimplify the issues addressed in the petition. It is more likely that individuals support repeal of the Act, but for differing reasons. For example, a particular user may agree that the Act does not improve animal welfare and gives succour to animal rights extremists, but disagree that it threatens livelihoods. Thus, signing such a petition is an "all-or-nothing" statement with no room for discriminating between (or even acknowledging) the different reasons as to why people may wish the Act to be repealed. Furthermore, it may be that the petition does not cover all of the objections that can be made against the Act and there are no means by which individuals can add any other objections they may have.

The above issues in turn have consequences for how an analysis of the petition is conducted and how the results are responded to by the government. After a petition closes the response is analysed quantitatively in terms of the number of signatures it attracted. Information is available from the e-Petitions website as to the ranking of petitions, in terms of their relative popularity. Therefore, analysts could see which issues appear to be of most importance to members of the public who engage with the system. A response to the petition is then drafted which attempts to clarify the government's position on the matter and respond to the criticisms made in the petition. However, since, as noted above, there is no means by which to discriminate between the particular arguments presented to endorse the petition, the stock response is not likely to adequately address the precise concerns of the public. Any answer, therefore, can only be very general and so fail to respond to the true reasons that citizens may have for adding their digital signature to the petition.

From the discussion that I have presented here, it is clear that e-Petitions do not provide a fine grained breakdown of the arguments presented, and thus any response sent to signatories cannot adequately address the differing viewpoints of the respondents. The issue with e-Petitions identified here also presents itself when other expressive and often popular, but ultimately unstructured, tools for opinion gathering are considered.

In the modern age, the Internet provides the public with a range of attractive means through which they can express their opinions widely and effectively, as described in Section 3.3.1. The unstructured tools identified in this section all suffer from another issue inherent in scenarios where no structure is applied to the arguments within the system: it becomes very difficult or impossible to collect and computationally analyse the huge number of differing positions submitted, each formulated using natural language. For example, the BBC News "Have Your Say" feature regularly attracts many hundreds of responses, however these responses generally consist of more than a simple "agree" or "disagree" statement. Often the respondent provides some background information on how he arrived at this conclusion, his opinion on other related topics, and/or voice his feelings of love or hate towards the topic under discussion.

Although it is easy to collect the text submitted to the system, analysing this text in order to gain reliable and meaningful information on the opinions of those who have responded is an extremely challenging task. Text mining, and more specifically, opinion mining, is a recent area of research that attempts to address the complexities of the task (e.g. [119], [80]). In contrast to methods in which the public are specifically invited to submit their opinions, opinion mining can be used to harness expressions of opinions that already exist, for example in blogs or online discussion forums. One of the difficulties here is that opinions are expressed in many different forms depending on the person who formulated the opinion and the context in which it is submitted. Some expressions may contain sarcasm which a human would detect easily, but natural text processing tools would probably not.

To further illustrate the challenges faced in analysing free text opinions, I consider a "Have Your Say" feature from the BBC News website published in 2004 around the topic of fox hunting[16]. The following are three responses received from different users to this particular topic of debate:

> *"If you were to leave the foxes alone, then they would like many other animals control their own population, they have a hierarchy, but because they are shot and hunted they breed randomly and in actual fact by killing them as we do we create more breeding and hence more foxes. However in favour of Hunting, I do believe it is part of a British Culture that is rapidly dying, because of bureaucrats and do-gooders that are in fact creating a lawless, racist world."*

This response appears to support the fox hunting ban, on the grounds of population control of the fox. However, the respondent then goes on to give a justification for repealing the ban on the grounds of it being part of the British Culture. It would be difficult for even a human moderator to analyse whether such a response is in favour or against the fox hunting ban. This highlights one of the issues of allowing free, unstructured text to be entered by users, thus not encouraging the respondent to commit to either agreement or disagreement.

A second user responded as follows:

> *"its nothing to do with a class war. its about behaving in a civilised way. So hunting isn't barbaric then? Great! Let's bring back bear baiting and cock fighting! The pro-hunt lobby make me sick."*

Despite not being explicitly specified, this response clearly agrees with the ban on fox hunting, on the basis that it is uncivilised and barbaric. The user employs some degree of sarcasm in his response, and it is exactly for reasons such as this that the necessity for a human moderator arises when analysing these responses.

The following is the response of a third user:

[16] http://www.bbc.co.uk/gloucestershire/getfresh/2004/10/hunting.shtml

"Ban it altogether!"

This response, although perhaps more simple to interpret than the others, does not give any information on why the respondent feels that a total ban on fox hunting should be introduced. Thus, this response is no more useful than a signature on an e-Petition.

Gathering opinions from other unstructured sources faces similar problems: Social networking sites, blogs, and other interactive websites and tools tend to fall into one of the two categories that I have identified: either they put forward an argument and ask the user whether he agrees, thus losing the detail of exactly why he agrees; or they allow the user to provide a free-text contribution in which the user can provide an identification of exactly what he disagrees with, but which causes difficulty when it comes to computational analysis of the resulting submissions, thus making it challenging to analyse a large volume of responses.

In this section I have identified a selection of unstructured tools which promote ease of use (and, in some cases, high expressivity), but do not provide enough structure to enable useful computational analysis to take place. Due to these shortfalls, these unstructured tools are unsuitable for use in an e-Democracy setting in which one wishes to obtain a fine-grained detailed analysis of a large volume of responses.

3.4.1.2 Structured Tools

In an attempt to overcome the problems associated with e-Petitions and other tools which promote expression of opinion, much research has concentrated on developing tools which are based on formal underlying theories of argument. This allows for arguments to be evaluated according to the particular formal structure that they adhere to. A large body of software tools exist to support decision making; in Section 2.2.5 I presented a survey of tools to support the argumentation process, and in Section 3.3.2 I discussed a subset of these tools that have been used within the domain of e-Democracy. In this section, I revisit the tools described in Section 3.3.2 and consider the shortfalls of these tools and the general issues encountered when applying structured tools within e-Democracy.

One particularly influential piece of work is the Zeno argumentation framework, discussed in Section 3.3.2.1. Zeno is described by its authors as a framework "designed to be used in mediation systems, an advanced kind of electronic discussion forum with special support for argumentation, negotiation and other structured forms of group decision making". The framework is based upon a formal model of argumentation (IBIS) that provides structure to the issues and their relative merit within a debate.

The fact that the arguments within these systems are based upon a formal structure has the implication that, firstly, all arguments input into the system must conform to this structure and, secondly, that once in the system, any interaction with the argument (for example, responses to the argument) must also conform to the structure. Due to this necessity to conform to the argument structure, the issue of usability arises when the system is presented to laypersons. Typically, to understand and interact with such argument structures requires some degree of knowledge and understanding of argumentation theory, which we can not assume the average person to possess.

Märker and Pipek [110] discuss the use of structured mediation tools (specifically Zeno) to gather public opinions on planning proposals. The motivation behind their experiments is that German law dictates that "whenever a new street or railway is built, whenever new industrial or commercial areas are planned, planning procedures are applied which should assure that the interests of the public community are not violated" [110]. In the test cases, affected citizens could inspect planning documents within a Zeno workspace. With regards to the structure imposed on discussions within the Zeno system, Märker and Pipek state that it requires users "to decompose and classify accurately formulated knowledge items when they enter them into the system" and that this "sometimes is difficult, and it might result in a loss of context".

They also state that their experiments show that "support and assistance by a moderator or a mediator is necessary", which naturally imposes limitations on the scalability of the system. This is a significant consideration in a domain such as e-Democracy, in which requiring the participation of a mediator would impose a significant limitation on the size of the target audience to which the system can be applied. Märker and Pipek also state that "Some citizens may have problems handling the system, or to classify and incorporate their statements into the discussion structure according to the issue-position-argument scheme of the model. Other participants could misuse the forum, being aggressive or insulting, or swamping it with irrelevant contributions".

The HERMES system, developed by Karacapilidis *et al.* and described in [74], is described by its authors as an "extension to Zeno". The HERMES tool is intended to be an extension of the hugely popular threaded discussion forums that are ubiqutous on Internet websites. HERMES attempts to address the issues described with unstructured systems by providing mechanisms for structuring discussions and providing reasoning mechanisms. Users can participate in electronic argumentation about a topic that is pre-defined by the system administrator.

Based on the elements entered into HERMES by the participants in each discussion, a visual tree is constructed in which each position submitted to the discussion is shown. In [90], an evaluation of HERMES was carried out with a discussion based on whether or not the establishment of non-state universities should be allowed in Greece. In this paper the authors discuss some of the feedback given by users during the evaluation. Amongst the issues raised by users was the issue that "it was difficult to associate correctly a new element they intended to contribute to another existing element" and that "participants felt that the electronic argumentation was quite demanding and required high levels of concentration and mental effort". Thus it is evident that even when a structured system is integrated with a format that is familiar to users (in this case, threaded discussion forums), users still apparently find it difficult to understand and interact with this structure.

Another tool based on Zeno is called DEMOS (Delphi Mediation Online System), discussed in Section 3.3.2.2. As described there, all discussions within DEMOS follow a particular proceedure, during each phase of which users make contributions and moderators analyse and summarise these contributions at the end of each phase. Such discussions often start out with a main topic of discussion which is broken down into smaller sub-topics that are individually discussed at length, before using the conclusions of these sub-topics to feed back a larger conclusion to the main topic of debate.

Although this moderator-guided form of discussion ensures that contributions are relevant and allows for any that are not relevant to be quickly discarded, it comes at the cost of requiring significant time and effort from a team of moderators. Intense moderation may be realistic when the user base of the system is small, but is likely to become impossible when the user base starts to grow. The issue of moderation and moderator-guided discussion has arisen in many of the structured systems discussed here. I now examine the issue of moderation, both in structured systems and unstructured systems.

3.4.2 Moderation

A number of the argumentation support tools that I considered so far in this thesis require the presence of a human moderator in order to support the process of argumentation. Moderation can be required for one of a number of reasons, including:

- To ensure that the *structure of discourse* is adhered to; ensuring that arguments are entered into the system in the correct format, and in the correct location.
- To prevent *abuse or spamming* of the system; removing redundant, duplicate, or irrelevant contributions.

The first point is relevant mainly to systems which are structured according to some formal theory of argumentation. Often, especially in cases where the user does not have a large amount of experience with the system, he will find the methods of argument confusing and hence could construct and locate his arguments incorrectly. This issue has been raised in relation to many systems which are based on formal models of argument, for example by the authors of HERMES (described in Section 3.3.2.3).

The second issue identified above is of particular concern in a system for opinion gathering in e-Democracy. Many of the topics discussed in such systems will be controversial and therefore liable to abuse by parties with strong opinions on the matter. Moderators are often required in systems where free text is permitted, to ensure that any offensive or irrelevant comments posted by users are filtered out before they appear in the debate.

An example of a system which requires a large amount of moderator-guidance is the DEMOS System (see Section 3.3.2.2), which requires human moderators at every stage of the process to develop the argument. Similarly the Carneades system, which has been trialed in an e-Democracy setting and is described earlier in this chapter, relies heavily upon the human facilitator to form a bridge between real life conversation of participants and the representation of the debate within the Carneades system. The use of a moderator (termed a "facilitator" by the authors) within Carneades is, therefore, necessary in order to ensure that users' views are correctly expressed within the system.

One of the main issues with systems which rely on moderator guidance is scalibility. Although it is realistic for a moderator to be able to sift through the contributions of a small number of users, if one was to promote such a system to a wider audience, such as the entire electorate of a particular country, then the moderator would be faced with a huge task in analysing the free-text contributions in order to refine the topic of discussion and draw conclusions. This would lead to a large amount of time, and ultimately money, being invested in the process of moderating and progressing debates.

The response to the issue by governing bodies seems, in many cases, to be the restriction of user expressivity in order to eliminate or reduce the requirement for system moderation. This can be seen in government e-Petitions (discussed in Section 3.3.1.1), which only allow users to respond with their name and email address, and no further comments.

Other, non-governmental projects use moderation in order to prevent the posting of irrelevant or offensive comments. For example, the BBC News Have Your Say feature described in Section 3.3.1.3 allows users to respond to news stories, but the users' comments do not appear on the website until they have been approved by a member of the BBC moderation team.

To summarise, moderation is required in cases in which users can submit free-text responses, especially where contributions are to be analysed in order to draw conclusions. In cases where the volume of users is large, the amount of moderation required is likely to be significant. In this section, I have considered some of the existing approaches to moderation in tools for e-Democracy. In the next section, I consider the issue of scalability in these systems.

3.4.3 Dealing With a Large Number of Respondents

The issue of dealing with a large volume of responses is one that must be considered when designing systems for e-Democracy, which a large number of geographically distributed users are to interact with. The problems that are encountered when a large number of responses are received present themselves both in tools which are based on free argument, and those which are based on formal structures.

For example, consider again the BBC News Have Your Say feature, an example of a method of collecting public opinion which is based on free argument. There is no limit on the number of users who can respond to such an article, however, since there is no method of analysing and summarising the submitted opinions, it is very difficult to obtain a true picture of the overall public opinion when there are a large number of responses. The same issue exists in blog comments and discussion forums in which a large amount of free text responses are provided.

Other unstructured systems attempt to overcome this problem by placing restrictions the amount of data that the user can submit. As discussed in the previous section, e-Petitions restrict the user to submitting his name and email address, and assuming that he agrees with all of the points raised by the e-Petition. Therefore, the only method of analysis that can be performed in this case is to count the number of responses received. Other systems, such as YouGov, place restrictions on the number of people who can take part in opinion gathering tasks, in order to reduce the possibility for irrelevant or duplicate contributions (as well as ensuring that participants fall within a range of demographics).

Although structured tools go some way to overcoming this problem by structuring contributions according to some model of argument, there still exist some problems when a large volume of responses are received. This is especially true in cases where the resulting data is visualised. By way of an example, I consider Debategraph[17], as discussed in Section 2.2.5.10. Debategraph attempts to overcome some of the issues present in systems such as the BBC "Have Your Say" feature by structuring arguments in order to make the links between different positions explicit. However, the structure employed by the software is proprietary, with no argumentation theory available to draw any kind of conclusions from the data within the system. Hence, the large amount of data in the system often does not lend itself well to graphical representation (see Figure 3.6). In order to overcome this issue, graphical interfaces must provide a mechanism of summarising (or hiding) the large amount of data present within the system, without losing the specific details of users' responses. Although the majority of the systems considered so far in this thesis are based on graphical interfaces, few of them effectively cater for a high volume of data.

In this section, I have outlined some of the issues faced in situations where a software tool is required to handle a large volume of responses. This is of particular concern in e-Democracy, where a true democratic system should give all citizens the opportunity to express their opinion on the topic at hand.

[17]Debategraph: http://www.debategraph.org

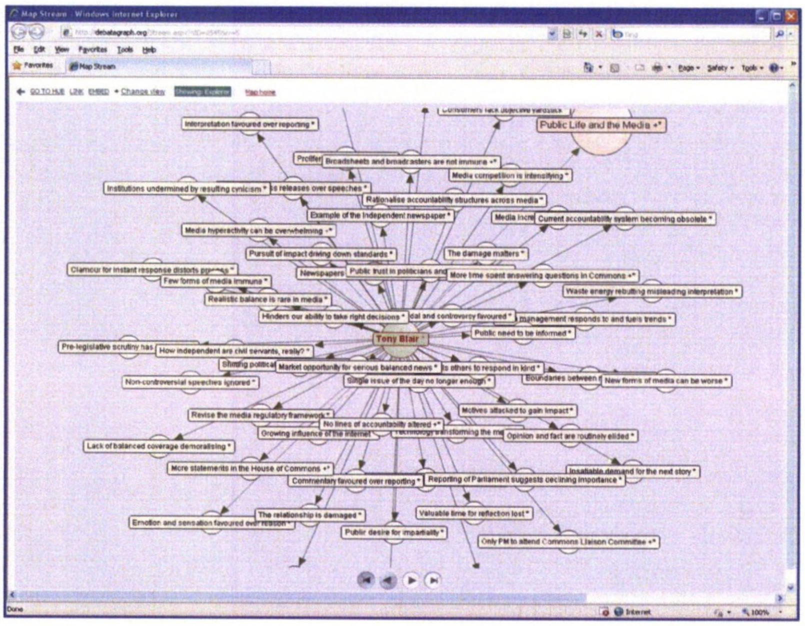


Figure 3.6: An example of a graph in Debategraph

3.5 Summary

In this section, I have discussed one of the main topics on which this thesis is based: opinion gathering in the domain of e-Democracy. I discussed traditional methods of gauging public opinion which pre-date the introduction of electronic methods of democracy, and described how these methods evolved through the 18th, 19th and 20th century.

I went on to introduce computational methods of opinion gathering, which were popularised by increased access to the Internet in the 1990s and 2000s. I discussed this in two parts; the first part discussed tools which are based on free, informal methods of argumentation. These methods include e-Petitions, as well as large scale media and social networking websites such as BBC News Online and Twitter, respectively. The second part of the discussion considered tools which are based on formal methods of argument, informed by scholarly research in the domain of argumentation theory. These tools included the Zeno framework of argument, an influential piece of research which has influenced other developments such as DEMOS, which I also described.

The final part of this chapter considered the issues inherent to current computational methods of gathering and analysing public opinion computationally. I started the discussion with one of the major issues, which is that of structured systems vs. unstructured systems. Whilst structured systems tend to provide more structure to arguments and hence allow for them to be evaluated easily, they are often more difficult to use and do not promote expressivity. I also discussed two other problems encountered in tools for computational analysis of public opinion; namely moderation and volume of responses.

In the next chapter, I examine how one particular structured method from argumentation theory, namely argumentation schemes, can be used to aid the process of democratic decision making.

Chapter 4

Practical Reasoning with Argumentation Schemes

4.1 Overview

In this chapter, I introduce practical reasoning, and discuss the application of argumentation schemes to practical reasoning. I discuss how policy justifications can be presented using argumentation schemes for practical reasoning, before considering how these schemes can be used in computational systems to present and gather public opinion on such justifications, in order to overcome the shortfalls of existing methods of opinion gathering identified in Chapter 3.

4.2 Practical Reasoning

In [55], Gauthier states that "a practical problem is a problem about what to do". Such a problem is therefore resolved when the person or group has decided on which course of action to take. Practical reasoning could therefore be seen as a bridge between the practical problem and the solution, involving reasoning about what action should be carried out in a particular scenario, according to some criterion. This criterion is relative to the agent(s) involved in carrying out the action and the particular circumstances in which it is being carried out. Such criteria may include factors such as moral beliefs, personal desires, financial prudency or the pursuit of a particular goal.

Despite practical reasoning being part of the everyday life of most people, more attention has been given to reasoning about beliefs. Reasoning about beliefs is important within the domain of Computer Science, and specifically Artificial Intelligence, in which intelligent agents are expected to be able to reason about what is true in the world. However, these agents are also required to possess the capability to reason about actions. In [11], Atkinson *et al.* state that "For software agents to have the capability of interacting intelligently with their environment they also need to be equipped with an ability to reason about what actions are the best to execute in given situations". This implies that software agents need to be able to carry out practical reasoning.

In some of the earliest literature on practical reasoning, Aristotle proposed its representation in the form of a syllogism. Generally speaking, a syllogism is a three-term argument which consists of a major premise, a minor premise, and a conclusion. The major premise asserts some universal truth such as "All men are mortals", whilst the minor premise states a particular truth like "Socrates is a man". The conclusion can be drawn from the combination of the major and minor premises (in this case, "Socrates is a mortal"). However, the process of concluding that Socrates is a mortal is theoretical reasoning, rather than practical reasoning, since it reasons about beliefs rather than about carrying out an action. In the practical syllogism introduced by Aristotle, the major premise identifies some good to be achieved, and the minor premise locates the good in the current situation.

Anscombe's article "On Practical Reasoning", published in [132], discusses the practical syllogism in some detail. Aristotle's own example of practical syllogism is provided, which is as follows:

> Dry food suits any human
> Such-and-such food is dry
> I am human
> This is a bit of such-and-such food

yielding the conclusion

> This food suits me

It is interesting to note that the conclusion of this example ("This food suits me") does not directly suggest that a particular action be performed, as one might expect in the practical syllogism. Rather, Aristotle seems to envisage an action (i.e. "I should/can/will eat this food") as following from the conclusion. Based on the work of Aristotle, others have gone on to give examples of practical reasoning which do conclude with the proposition of carrying out an action, e.g. in [76]:

> I'm to be in London at 4:15
> If I catch the 2:30 I'll be in London at 4:15
> So I'll catch the 2:30.

This abductive form of practical reasoning is a useful alternative to the deductive version originally proposed and used by Aristotle. In [11], Atkinson *et al.* identify one of the problems with this abductive form of the practical syllogism, namely, that:

- As abduction is being used, there may be alternative ways of achieving the goal
- Other actions (A2) may be excluded by carrying out the action suggested (A1), and A2 could have consequences that are more desirable than the stated goal
- The suggested action could have consequences in addition to the goal specified, some of which may be so undesirable that we abandon pursuit of the goal.

Thus, one should consider alternative actions and goals, in addition to possible consequences (side effects) of carrying out the action and determine whether or not they are desirable. This differs considerably from reasoning about beliefs, where if we have knowledge of what is true or not true in the current state of the world, we can not *choose* to believe something different. However, it is possible to choose whether or not to believe facts that are imparted to us by others based on factors such as our current beliefs and social factors such as trust, reliability and perceived motives of the other party.

The core difference between reasoning about actions and reasoning about beliefs is summarised by Atkinson in [5]: "Unlike beliefs as to what is true, when the world being as it is means that there is a right and wrong answer, different people may rationally make different choices of goals and actions". That is, although there is little choice to be made about what we believe is true in the current state of the world, actions and goals are subject to far greater flexibility - we can choose how we want the world to look in future (goals) and how we wish to achieve this (actions), perhaps selecting between a number of competing goals and actions in accordance with our own particular preferences.

It is these preferences that are considered in more recent definitions of practical reasoning, e.g. that of Bratman [29]:

> "Practical reasoning is a matter of weighing conflicting considerations for and against competing options, where the relevant considerations are provided by what the agent desires/values/cares about and what the agent believes." [29, p. 37]

Here, Bratman represents preferences as "what the agent desires/values/cares about", and states that the agent should take into account such preferences in addition to the beliefs he holds. The notion of "what an agent values" is an important part of the rest of this thesis, in which I develop a software tool which is based on practical reasoning in terms of social values. In Section 4.3, I discuss how practical reasoning can be carried out with reference to the social values promoted by particular actions, and in Chapter 5 I introduce a practical implementation of a software tool that employs value-based practical reasoning. In the work on value-based reasoning, a "value" typically refers to a general social interest that a person, group, or community (which Perelman terms an "audience", as discussed in terms of argument evaluation in Section 2.1.2.2) aspires to, without specifying exactly how he, she or they wish to achieve it. Such values play an important part in practical reasoning as they motivate the choice of particular goals, and therefore particular actions to achieve these goals. Values are often used, both explicitly and subconsciously, for our own internal decision making and when we present our arguments to others. An example of a value could, for example, be "tolerance". We can define this as a value because it specifies a general state of the world that should be achieved, but does not go into detail about how this should be achieved (as a goal would). The concept of a value (within this thesis I will occasionally refer to this kind of value as a "social value", to prevent confusion with a numerical value) also provides some reason as to why two people who hold different value preferences, yet the same beliefs about the world, will have different opinions and may have difficulty in convincing one another of their respective points of view. In [146], Searle presents a discussion on subjective disagreement based upon subscription to particular values. He addresses practical reasoning in his discussion of rationality and shows how and why disagreements occur in rational agents.

In this section, I have discussed the motivation for practical reasoning and how it applies to computational agents. I considered some of the earliest work by Aristotle on practical reasoning, and how this has been developed in more recent literature. In the next section I discuss how argumentation schemes, a method of structuring argument, have been applied to practical reasoning.

4.3 Practical Reasoning with Argumentation Schemes

In this section I discuss how argumentation schemes, introduced in Section 2.1.2, can be used to support the process of practical reasoning. I then consider how the critical questions associated with the schemes can be used to challenge government policy justifications.

In order to overcome the problems encountered when practical reasoning is treated as a syllogism (discussed in Section 4.2), practical reasoning has been considered as a type of presumptive argument, whereby an argument provides a presumptive justification for carrying out the action. Importantly, this argument can be challenged and withdrawn if appropriate, thus providing the groundwork for overcoming the problem described earlier with the practical syllogism. By challenging the presumptive arguments the opportunity arises to consider alternatives, for example alternative actions and alternative goals, to ensure that the proposed argument really does promote carrying out the action that is "best" for a particular agent.

One of the earliest representations of practical reasoning in terms of argumentation schemes was Toulmin's schema [150], as described in some detail in Chapter 2. In this representation, a number of elements are provided in order to represent the argument, including a *claim* (conclusion of the argument), *data* (argument premise) and a *warrant* (licences the derivation of the claim from the data). Toulmin's schema proved popular due to the expressivity it afforded in presenting and justifying arguments, and formed the basis of a number of implemented systems ([23], [97], [173]). Despite the popularity of the schema, it lacks some of the elements that allow identification of the exact points of disagreement in an argument. For example, the argumentation schemes introduced by Walton in [162] provide critical questions in order to explicitly identify the elements of the argument that are called into question by an attacker. In contrast, Toulmin's schema provides no such mechanism by which specific elements of an argument can be attacked, other than simple rebuttal of the claim put forward.

Since the introduction of Toulmin's scheme, considerable advances have been made in representing practical reasoning in terms of argumentation schemes. The work of Walton concentrates on defeasible argumentation through the use of argumentation schemes (as discussed in Section 2.1.1.2), with one such scheme concentrating on practical reasoning. I now turn to consider the work of Walton in practical reasoning, and how this has been extended to support explicit representation of value-based practical reasoning.

4.3.1 Walton's Practical Reasoning Scheme

In [162], Walton provides an account of presumptive reasoning in terms of argumentation schemes and Critical Questions. He provides two argumentation schemes, which he names the *necessary condition scheme* and the *sufficient condition scheme*. The *necessary condition scheme* is stated as follows[1]:

> G is a goal for a
> Doing A is necessary for a to carry out G
> Therefore a ought to do A

While the *sufficient condition scheme* is stated as follows:

> G is a goal for a
> Doing A is sufficient for a to carry out G
> Therefore a ought to do A

In both schemes, a represents an agent, A an action, and G a goal. Associated with these schemes are four critical questions, which challenge the presumptions in the schemes:

[1] Walton gives a more detailed account of these argumentation schemes for practical reasoning in [166], with five critical questions rather than four. However, the development of Walton's work described in Section 4.3.2 is based upon the version given in his 1996 book, and so it is this version that I consider here.

CQ1: Are there alternative ways (other than A) of realising G?

CQ2: Is it possible for a to do A?

CQ3: Does a have goals other than G that should be taken into account?

CQ4: Are there other consequences of bringing about A that should be taken into account?

These critical questions highlight the defeasible nature of this particular type of reasoning - by posing any of the critical questions against the argument, an attacker is given the opportunity to call into question any of the presumptions stated by the proponent of the argument. When posing and responding to critical questions, the burden of proof shifts between the proponent of the argument and the attacker. The burden of proof is the obligation of one side of a dispute (i.e. the attacker or the proponent of the argument) to provide evidence to support their particular position. When a critical question is posed by an attacker, the burden of proof shifts to the proponent of the argument to provide a reasonable defence of his argument, after which point the burden of proof shifts back to the attacker. In [125], Prakken *et al.* examine how the burden of proof shifts during persuasion dialogues, using Walton's Argument from Expert Opinion scheme.

In [162], Walton provides a further 25 argumentation schemes to support different types of argument, including arguments based on expert testimony and those based on observed correlations. A more recent publication by Walton [166] provides a compendium of 60 schemes, covering an even wider range of natural types of argument. I discuss a selection of these schemes further in Chapter 6, however for the remainder of this chapter I return to discuss practical reasoning.

I will now discuss a development of Walton's practical reasoning scheme by Atkinson *et al.* This development introduces the notion of a "value" in order to provide a reason for aspiring to achieve a particular goal.

4.3.2 Atkinson's Development of the Practical Reasoning Scheme

In [11], Atkinson *et al.* consider the practical reasoning argumentation schemes developed by Walton, and extend these schemes with the aim of developing a scheme that provides explicit representation of the components of a practical reasoning problem. In order to achieve this, Atkinson *et al.* focus on Walton's *sufficient condition scheme* ("SCS"). The justification given for considering this scheme over the *necessary condition scheme* ("NCS") is that "[NCS] is a special case [of SCS] in which CQ1 (Are there alternative ways (other than A) of realising G?) is answered in the negative".

Whereas Walton's scheme was based around the achievement of a particular goal G, Atkinson's extended scheme separates the goal into three distinct elements: States, Goals, and Values. States are defined as "a set of propositions about the world to which we can assign a truth values", Goals as "propositional formulae on this set of propositions", and values as "functions on goals". The distinction between states and goals is made in order to differentiate between the side effects of an action (states), and the subset of these side effects which an agent specifically wishes to attain (goals). Meanwhile, a value provides a reason for the agent wishing to obtain the particular goal.

This notion of a value is particularly useful in automated computational tools, as it enables representation of the particular reason that we wish to obtain the goal. Within the software tool that I describe in Chapter 5, values are used in order to analyse the relative merit of particular arguments and the actions that they presumptively licence. As each action can promote more than one value, and each value can be promoted by more than one action (through the achievement of one or more goals), arguments can be classified according to the value(s) that they promote.

Atkinson's expanded scheme for persuasion over action is stated in [11] as follows:

PR1: In the circumstances R,
we should perform action A,
to achieve new circumstances S,
which will realise some goal G,
which will promote some value V.

A total of sixteen critical questions are proposed to accompany the scheme, an expansion on the original four that Walton proposed for his practical reasoning scheme. The critical questions are as follows:

CQ1: Are the believed circumstances true?

CQ2: Assuming the circumstances, does the action have the stated consequences?

CQ3: Assuming the circumstances and that the action has the stated consequences, will the action bring about the desired goal?

CQ4: Does the goal realise the value stated?

CQ5: Are there alternative ways of realising the same consequences?

CQ6: Are there alternative ways of realising the same goal?

CQ7: Are there alternative ways of promoting the same value?

CQ8: Does doing the action have a side effect which demotes the value?

CQ9: Does doing the action have a side effect which demotes some other value?

CQ10: Does doing the action promote some other value?

CQ11: Does doing the action preclude some other action which would promote some other value?

CQ12: Are the circumstances as described possible?

CQ13: Is the action possible?

CQ14: Are the consequences as described possible?

CQ15: Can the desired goal be realised?

CQ16: Is the value indeed a legitimate value?

Thus, this extension to Walton's work on practical reasoning allows one to instantiate justifications for carrying out a particular action. In order to do this, one must provide a statement of the current situation, the situation that one wishes to achieve by carrying out the action (the "new circumstances"), the subset of the new circumstances that are a desirable reason for carrying out the action (the "goal"), and the social value promoted by this goal. The defeasible nature of the scheme is captured by the critical questions which can be posed against any such instantiation.

Atkinson's practical reasoning scheme has been used in [10] to develop a formalism allowing BDI agents to reason and argue about practical action. In [7], Atkinson and Bench-Capon described how the scheme can be defined in terms of an action-based alternating transition system [155], a well-known model for representing the effects of actions of a group of agents.

In the next section, I discuss how practical reasoning can be used to overcome some of the problems faced in public opinion gathering in e-Democracy. I then go on to instantiate a particular political debate using Atkinson's practical reasoning argumentation scheme, in order to demonstrate another useful application of the scheme.

4.4 Policy Justifications as Practical Reasoning

4.4.1 Motivation

One important question that faces governments and other governing bodies is that of "What should we do?" - that is, given a set of circumstances and a goal that needs to be achieved, exactly what action(s) should be carried out (or what policies should be implemented) in order to achieve these goals. In a democratic society, it is important that the decision of what a government should do is made in conjunction with the views and the opinions of the public, and indeed the fact that a policy proposal is favoured by a majority of citizens is likely to be a good reason for adopting that particular policy.

The question of "What should we do?" poses a practical problem, and therefore practical reasoning can be used to determine the solution. The solution should be in the form of an action that the government should carry out in the current circumstances in order to reach the goals. By way of an example, I now consider a policy based around fox hunting in Britain, a policy that I discussed in Section 3.3.1.1 in terms of an e-Petition that has been implemented surrounding the topic. This particular e-Petition suggested repealing of the ban on fox hunting that was implemented by the British government in 2004.

As described in Section 3.4.1.1, the results of such an e-Petition might not be particularly useful to a government wishing to know exactly why their citizens have signed the petition. This is because petitions often consist of a number of separate justifications in favour of a particular proposal (in this case, repealing the fox hunting ban) conflated into one statement. Thus, when analysing the response to the e-Petition, the government has no information on exactly which of the numerous justifications are agreed and disagreed with by the majority of respondents. Hence, responding to such an e-Petition and addressing the concerns highlighted by citizens becomes a difficult, if not impossible, task.

Applying practical reasoning to an issue such as the fox hunting debate can go some way to providing a solution to this problem. The practical reasoning argumentation scheme described in this section, with the critical questions associated with the scheme, allow for the various justifications for the proposed action to not only be described, but also challenged and refuted. By using this mechanism, the public could be given the opportunity to provide a fine-grained critique of the underlying justifications, thus allowing the government to see exactly which points cause the most contention amongst the public. Practical reasoning could therefore either be used as an alternative to an e-Petition, or after a popular e-Petition has closed in order to solicit further information from citizens on exactly why they agree or disagree with a particular proposal.

4.4.2 An Example Based on Fox Hunting

I now consider the justifications presented for the fox hunting e-Petition in Section 3.4.1.1, and discuss how different respondents to such a debate may have differing opinions on why each of the facts presented in the justifications is true or not. In the context of an e-Petition, these differing opinions can not be stated. I will discuss how far practical reasoning using argumentation schemes can go in representing these differing opinions.

I start with a reminder of the justifications presented in the fox hunting e-Petition:

> Petitioners know that The Hunting Act 2004: has done nothing for animal welfare; threatens livelihoods in the longer term; ignores the findings of Lord Burn's Enquiry; gives succour to animal rights extremists; is based on political expedience following the Prime Minister's unconsidered response on the television programme Question Time in 1999; is framed to persecute a large minority who support a traditional activity; does not command popular support in the country except amongst the uninformed and mal-advised.

Let us consider the different types of attack that could be posed against each of these justifications. This analysis is not intended to be a comprehensive account of all modes of attack, but rather a summary of possible disagreements in order to motivate the discussion of how practical reasoning can address these attacks. I consider the justifications in the order that they are presented in the e-Petition:

Statement 1: The Hunting Act 2004 has done nothing for animal welfare

This particular statement highlights one of the issues inherent to the presentation of justifications in unstructured systems - namely the issue of clarity. The phrasing of this particular justification does not clearly state exactly why the proponent of the argument feels that animal welfare is suffering. Indeed, the phrase "done nothing" is ambiguous - is the proponent implying that the welfare of animals has worsened as a result of the fox hunting ban, or that is has simply not improved? And what exactly are the reasons for this?

Due to the ambiguity of this particular statement, there are a number of different ways in which a respondent may disagree with it. For example, one respondent could believe that the ban on fox hunting has improved animal welfare, because fox hunting was less humane than other methods introduced. Another respondent could believe that animal welfare is not important, whilst another could believe that although the ban has done nothing for animal welfare, repealing the ban will not improve the situation.

Statement 2: The Hunting Act 2004 threatens livelihoods in the longer term

This statement is, again, rather vague. It is not clear how the proponent feels that livelihoods would be threatened by the ban, and how the repealing of the ban would prevent this from happening. It is obvious that this particular statement is appealing to a different social value than the statement regarding animal welfare, although this is not specifically stated.

Disagreements with this particular justification could focus around the situation in the past, for example by stating that it was not fox hunting itself that created livelihoods in the first place. Another respondent may feel that livelihoods will actually be improved in the long term, due to a side effect of the fox-hunting ban. Another could feel that repealing the ban will threaten livelihoods to a far greater degree than having the ban in place (for example, because it will result in the public not giving business to establishments that support fox hunting).

Statement 3: The Hunting Act 2004 ignores the findings of Lord Burn's Enquiry

Here, the proponent of the argument in favour of repealing the ban is questioning the reasons for implementing the ban in the first place. This argument seems to be slightly different in nature to the others considered so far, as it challenges the reason for implementing the ban, rather than suggesting that a bad state of affairs have resulted as a consequence of the ban.

As this particular statement relies on the opinion of an expert (Lord Burns), the respondent to any such justification may wish to challenge other aspects of the justification rather than just the basic practical reasoning aspects of it (for example, a respondent may feel that Lord Burns is not in a position to know about fox hunting). Although this goes beyond basic practical reasoning, it is a topic which I return to in Chapter 6, where I discuss how other argumentation schemes can interact with the scheme for practical reasoning.

A respondent who is familiar with the details of the Lord Burn's Enquiry may wish to pose other attacks - for example by stating that the Lord Burn's enquiry is not actually ignored. Another attacker may wish to challenge the statement by proposing a different course of action (to repealing of the ban) which would adhere to the findings of the Lord Burns enquiry. Some audiences may believe that the Lord Burn's Enquiry is unimportant, and hence state that the consequences (presumably "taking heed of the enquiry", or similar) do not need to be achieved. Finally, an attacker may feel that repealing the ban will not rectify the damage caused by ignoring it in the first place, effectively stating that the consequences are not possible.

Statement 4: The Hunting Act 2004 gives succour to animal rights extremists

This particular justification for repealing the fox hunting ban centres around the perceived support given to animal rights activists as a result of the ban. It is interesting that the proponent of the argument chose to use the term "extremists", as he seems to be branding all those who believe that fox hunting is a cruel sport as "extremists". The government may wish to re-consider this wording if they were to present this debate to the public, to avoid alienating those who believe that fox hunting is a cruel sport, yet believe that the ban should be repealed due to the strength of another justification.

A respondent to this particular justification who supports the work of the animal rights "extremists" may object to the justification on the grounds that repealing the ban will result in disrespect towards those who have campaigned for the ban. Alternatively, such a respondent may pose a disagreement with the statement as a whole, feeling that the ban does not give succour to animal rights extremists. In a similar way to the third statement, it is not clear exactly what the consequences of repealing the ban will be in this case. Succour has already been given to the animal rights extremists, and some respondents may feel that the repealing of the ban will not undo this. This is again an objection to the consequences of performing the action.

Statement 5: The Hunting Act 2004 is based on political expedience following the Prime Minister's unconsidered response on the television programme Question Time in 1999

As the statement is rather brief and does not give specific details about the exact response given by the Prime Minister, I suspect that many users who are responding to such a petition would not be familiar with the "response" referenced here (made over 10 years ago) and hence would not be persuaded by the justification. Of course, this in itself is an attack that can be levied against the argument.

Another respondent may believe that repealing the ban will only work further against the government, reducing public confidence in the policies implemented by the government, and thus perhaps reducing trust in, and hence the authoritative power held by, the government.

Statement 6: The Hunting Act 2004 is framed to persecute a large minority who support a traditional activity

This justification for repealing of the fox hunting ban is aimed towards those who enjoyed fox hunting before the ban was put in place, or at least to those who sympathise with the recreational element of hunting. The use of the word "persecute" could be somewhat controversial, and thus lead respondents to question the truth of this circumstance statement. This raises another interesting point regarding the phrasing of justifications in a political debate - using emotive (and perhaps biased) statements such as "persecute" and "traditional activity" could evoke respondents into responding to the whole debate in a particularly negative (or positive) manner.

Respondents could pose other attacks against this particular justification; for example by claiming that the minority is not "large" in the context of the size of the whole population, or that the activity is not "traditional". All of these attacks present a challenge to the current circumstances presented by the justification. Respondents who appreciate the harm done to those who enjoy the activity, but do not support repeal of the ban, may attack this justification by suggesting that an alternative action could satisfy fox hunters (for example, allowing fox hunting only in a restricted area, or only using particular methods).

Statement 7: The Hunting Act 2004 does not command popular support in the country except amongst the uninformed and mal-advised

Again, this statement employs rather biased and emotive language in branding all of those who do support the ban on fox hunting as "uninformed" and "mal-advised". A government wishing to obtain a representative, wide-ranging set of views on a debate such as this should probably consider re-phrasing such a justification considerably.

In the context of an e-Petition this kind of language is not such a big issue, as the proponent of the position is actively trying to appeal to those who share such views.

The most likely attack on this justification is by those who do support the ban and do not consider themselves "uninformed" or "mal-advised". This poses an attack against the stated circumstances. Other attackers could believe that although the ban does not command popular support, a full repeal of the ban would not command popular support in the country either.

4.4.2.1 Discussion

In this section, I have discussed how a popular debate has been presented to the public and the different modes of attack that a respondent may wish to levy against the various justifications that comprise the debate. By examining the justifications put forward, we can see that there are a wealth of objections and challenges that can be proposed against them. When any government proposes the introduction of a new policy, it is highly important that all such objections and challenges are considered and responded to if appropriate. Responding to objections may involve the government revising the policy, re-wording the policy justifications, or presenting additional information to the public in order to support the justification.

It is clear from the discussion presented in Chapter 3 that e-Petitions, an existing method of gathering public opinions on government topics, only possesses the capability for very general attacks to be posed against the whole topic of debate. The example outlined in this chapter illustrates exactly why this is not adequate if a government wishes to determine exactly why its citizens disagree. In Section 4.3, I discussed how argumentation schemes could be used to represent practical reasoning problems in the form of prima facie justifications and challenges that can be made against these justifications through the use of critical questions. I now discuss how this approach can be used to enhance democratic opinion gathering.

4.4.2.2 Representation in the Practical Reasoning Scheme

So far, I have described the fox hunting debate in terms of a justification for the proposed action of repealing the fox hunting ban, as presented on the British government e-Petition website. I will now consider how this debate could be represented as an instantiation of the practical reasoning argumentation scheme, to demonstrate how this approach allows for structured representation of political arguments. I approach the discussion from the point of view of a government who has received the results of the fox hunting e-Petition, and now wishes to glean further information from its citizens: Why is there such a large agreement with repealing the fox hunting ban? Which of the justifications presented in the petition are agreed with most?

One way that the government could theoretically solicit opinion on these topics is by allowing citizens to give free text responses, for example by setting up a simple webpage which poses such questions to users and stores responses in a database. However, the fox-hunting e-Petition received almost 44,000 signatures. If all of these people were to submit data using such a system, the amount of natural-language data to analyse would be huge. One can imagine the amount of work that a human workforce would be faced with if they were to attempt to gather useful conclusions from this data. Thus, the problem with unstructured methods described in Section 3.4.1.1 arises.

If we consider the argumentation scheme for practical reasoning defined by Atkinson *et al.* [11], which is stated fully and described in Section 4.3.2, we see that the critical questions associated with this scheme allow for a wide-ranging set of attacks to be posed against an argument. To demonstrate how argumentation schemes could be applied in the particular scenario described here, I must first instantiate the scheme with the details of the fox hunting debate. In order to achieve this, I will represent each of the justifications presented in the petition as an instantiation of the practical reasoning scheme. In order to instantiate the practical reasoning scheme I will need to supply each of the presumptions that make up the scheme (current circumstances, action to be performed, consequences of the action, the goal, and the social value promoted by the goal), for each justification. Some of these presumptions are not specifically stated in the e-Petition justifications (for example, social values), and hence I will need to decide on the appropriate presumption myself.

For example, the justification "The Hunting Act 2004 threatens livelihoods in the longer term" simply appears to describe the undesirable current circumstance. The consequence of repealing the ban is not stated, but it is presumably that "More jobs will be created in the countryside", with the goal of "Removing the danger to livelihoods", which perhaps promotes the social value "Prosperity". From this, we can see that instantiating the practical reasoning argumentation scheme requires somewhat more effort than, for example, presenting the justifications in an e-Petition. Although this makes the initial process of creating a position more time consuming, it carries the advantage of requiring the proponent to carefully think out his position.

A full account of the argumentation scheme instantiations that I have extracted from the e-Petition justifications are as follows. Some of the justifications listed in the e-Petition have been discarded; I present a justification for this later.

1. In the current situation *Less humane methods of controlling fox population have been introduced.* We should *Repeal the fox hunting ban.* This will achieve *A reduction in the number of foxes*, which will realise *Less use of inhumane fox population control methods*, promoting *Animal welfare.*

2. In the current situation *The ban affects the livelihoods of those who make a living from hunting.* We should *Repeal the fox hunting ban.* This will achieve *An increase in jobs in the countryside*, which will realise *Better livelihoods for those*

who make a living from hunting, promoting *Prosperity.*

3. In the current situation *The ban ignores the findings of a government inquiry.* We should *Repeal the fox hunting ban.* This will achieve *Taking heed of government enquiries*, which will realise *Improved public perception of the government*, promoting *Consistency.*

4. In the current situation *The ban gives succour to animal rights extremists.* We should *Repeal the fox hunting ban.* This will achieve *Withdrawal of support for animal rights extremists*, which will realise *Support for more moderate views*, promoting *Balance.*

5. In the current situation *The ban prejudices a large minority who enjoy hunting with dogs.* We should *Repeal the fox hunting ban.* This will achieve *Removal of the prejudice against people who enjoy fox hunting*, which will realise *The personal enjoyment of a large minority of people*, promoting *Equality.*

By completing the task of instantiating such an argumentation scheme, the proponent is forced to consider his position in a logical way, starting from the circumstances, then the action that he wishes to perform in these circumstances and the desirable consequences and goals that will follow from performing the action. Finally, the proponent must summarise the overall merit of achieving this goal in the form of a social value. This fine-grained level of detail ensures that the proponent develops a position that makes sense and contains all of the elements relevant to the practical reasoning problem.

When examining the above instantiations of the argumentation scheme, one may notice that two of the justifications originally presented in the e-Petition are absent. I decided to omit these justifications from the practical reasoning version of the debate for differing reasons. The first justification that I omitted was "The Hunting Act 2004 is based on political expedience following the Prime Minister's unconsidered response on the television programme Question Time in 1999". I chose to omit this particular justification for two reasons; firstly, there is a lack of an explicit explanation of this "unconsidered response"; secondly, this episode of Question Time is now over ten years old, and hence the average citizen is not likely to remember it in any great detail. The second omitted justification was "The Hunting Act 2004 does not command popular support in the country except amongst the uninformed and mal-advised". I decided not to include this in the practical reasoning representation of the debate because the strong wording and implication of it is perhaps suitable for a petition, but not really suitable for a government to use to gather a wide range of unbiased reviews. Rather than being a justification for repealing the ban, it appears to be the airing of a grievance towards those who do not support fox hunting.

Having instantiated the fox hunting debate using the practical reasoning scheme, it is now possible to see the wide range of challenges that can be posed against the arguments using the critical questions associated with the scheme. For example, if we consider the challenges that I discussed as being possible against Statement 1 (now encapsulated in Justification 1) in the earlier discussion, we see that critical questions exist to cater for all of these challenges.

In Section 4.3.2 I gave a full listing of the critical questions associated with the practical reasoning scheme. I now instantiate these critical questions with the relevant presumptions from Justification 1, to demonstrate the scope of attack:

CQ1: Is it true that *less humane methods of fox control have been introduced*?

CQ2: Assuming *less humane methods of fox control have been introduced*, does *repealing the ban* have the consequence of *reducing the number of foxes*?

CQ3: Assuming *less humane methods of fox control have been introduced* and that *repealing the ban* has the consequence of *reducing the number of foxes*, will *repealing the ban* bring about *less use of inhumane fox population control methods*?

CQ4: Does *less use of inhumane fox population control methods* realise *animal welfare*?

CQ5: Are there alternative ways of realising *a reduction in the number of foxes*?

CQ6: Are there alternative ways of realising *less use of inhumane fox population control methods*?

CQ7: Are there alternative ways of promoting *animal welfare*?

CQ8: Does *repealing the ban* have a side effect which demotes *animal welfare*?

CQ9: Does *repealing the ban* have a side effect which demotes some other value?

CQ10: Does *repealing the ban* promote some other value?

CQ11: Does *repealing the ban* preclude some other action which would promote some other value?

CQ12: Is it possible that *less humane methods of fox control have been introduced*?

CQ13: Is *repealing the ban* possible?

CQ14: Is it possible to achieve a *reduction in the number of foxes*?

CQ15: Can *less use of inhumane fox population control methods* be realised?

CQ16: Is *animal welfare* indeed a legitimate value?

We can see that these sixteen critical questions provide any respondent with a wide range of possible critiques.

I now consider again the first statement presented in the e-Petition, which is that "The Hunting Act 2004 has done nothing for animal welfare". I consider again the possible ways in which a respondent may disagree with this statement, as identified earlier. I then consider how these disagreements can be characterised using the critical questions associated with the argumentation scheme:

- **The ban has improved animal welfare:** In its simplest form, this could be posed as an attack against the circumstances of the argument using CQ1 ("Are the believed circumstances true"). Alternatively, it could be posed using CQ7 ("Are there any alternative ways of promoting the value"), by suggesting that the action of keeping the ban in place would promote animal welfare.

- **Belief that animal welfare is unimportant:** This particular attack is easy to formulate once the justification has been instantiated using the practical reasoning scheme, as there is explicit representation of social values. While different respondents to the debate may agree with the factual information presented (i.e. circumstances, consequences, goals etc.), social values are very much subjective. The attack presented here is characterised in CQ16 ("Is the value indeed a legitimate value?"). More elaborate versions of this attack are possible using other critical questions; for example CQ9 ("Does the action have a side effect with demotes some other value?"), which implies that the respondent feels that the stated "other value" is more important than animal welfare.

- **Repealing the ban will not do anything for animal welfare:** This is a fairly general attack when posed against the practical reasoning instantiation of the justification, which the attacker must refine in order to determine the correct critical question to use. For example, CQ4 states that the goal (less use of inhumane fox population control methods) will not achieve the value of animal welfare. This assumes that the goal will be reached. However, the respondent may believe that the goal will not be reached at all (because, for example, inhumane methods of fox control will still be used) and hence should pose CQ3.

The above serves as an example of how critical questions can accommodate the natural criticisms that one may have against any particular practical reasoning argument. If one examines the other statements in the e-Petition and the attacks possible against these, it is again possible to see that the critical questions offer a comprehensive method of posing at least a generalised form of these attacks.

Here, I have discussed how a political argument can be instantiated using the practical reasoning scheme. I have identified the key advantages of this approach - namely the expressiveness offered by the argumentation scheme and the way in which proponents of arguments are forced to develop their thoughts into a coherent position. I have developed an informal account of the kind of challenges that could be posed against the particular political argument discussed here, and I have noted how the critical questions associated with the argumentation scheme allow these challenges to be posed effectively.

4.5 Embodying the Practical Reasoning Scheme in a Computational Tool

The work presented so far in this chapter introduces practical reasoning, and motivates its use in gathering public opinion on topics of political debate. I have introduced some of the existing work on the use of argumentation schemes in representing practical reasoning problems, and instantiated an example political debate to illustrate the usefulness of the representation.

The discussion so far has been based on the theory of using this representation. Of course, if the theories are to be used by real governments around the globe to gather opinions over the Internet from their citizens, then thoughts must be turned to how these theories can be implemented in a software system. In this section, I will discuss a number of different software tools which implement such schemes in order to provide a basis for the gathering of opinion, including Parmenides, a tool which I go on to develop throughout the rest of my thesis.

A number of software tools exist for the purpose of argument representation in the form of argumentation schemes, and despite the fact that most of them were developed for domains other than e-Democracy, they are nevertheless worthy of consideration in this chapter as they go some way to bridging the gap between the theory of schemes and their implementation in software. Some of the tools that I describe in this section have already been briefly outlined in Chapter 2, and the discussion of structured tools for e-Democracy in Section 3.4.1.2. For this reason, the discussion of the tools in this chapter focuses specifically on their implementation of argumentation schemes and their application to e-Democracy. I begin with the Carneades tool.

The Carneades software tool (introduced in [61]) was designed to "support a range of argumentation tasks, including argument reconstruction, evaluation and visualisation". The implementation of argumentation schemes in the tool allows the user to construct arguments, which are graphically connected to other arguments to form supporting or attacking relationships between them. Arguments can then be evaluated to determine which ones remain un-defeated. Although this type of tool is useful for representing and evaluating arguments, it is not intended for use by those who do not have a strong knowledge of the underlying argumentation theory. If one was to use a tool such as this in the domain of e-Democracy, it would be quite possible to train a specialist to create initial debate positions within the system, however it might be too difficult for ordinary citizens to interact with the initial positions.

The Araucaria tool [144] is also one which is designed for academic use, rather than for laypersons. It allows for textual arguments to be constructed in terms of argumentation schemes, which is achieved by allowing the user to represent the relationships between various positions as a graph. Although this goes some way to teaching laypersons how to represent arguments in this formal structure, the fact that the structure is present is still likely to confuse laypersons and dissuade them from participating.

Other tools, despite not being directly based on argumentation schemes themselves, have attempted to structure debates about democratic decision making problems. As early as 1997, Gordon and Karacapilidis undertook the research project of designing and implementing a mediation system to be used on the Internet to enable interested citizens to take part in electronic discussions with government officials planning public projects. Despite the fact that the Zeno system was specifically designed to be used by laypersons in order for them to share their views, later publications noted that "Some citizens may have problems handling the system, or to classify and incorporate their statements into the discussion structure" [110]. The fact that the Zeno system still presents itself to citizens in the form of a structured system, requiring users to understand this structure, means that it falls down when applied in any domain where users are unable or unwilling to learn how the structure works.

More recently, the theories behind Zeno have formed part of the basis for the DEMOS System[2], which their website describes as "a web-based platform enabling fruitful and constructive debate between citizens and politicians". The system is based on discussions which take place with the aid of a human moderator. Discussions take place in three phases, which are defined as "broadening, deepening and consolidating". Both within and after each of these stages, the moderator is required to ensure that discussions stay on topic, to "cluster and structure" the discussions and to visualise the relationships between the various positions put forward. Although this system does go some way to overcoming the "structure vs. ease of use" problem by employing moderators to structure the submissions of participants, this leads to a large amount of labour being required to analyse and structure this data. It also makes the system susceptible to deliberate or accidental moderator bias - for example, the moderator of a debate may interpret a user's submission in a different way than it was intended, thus skewing any later analysis of the data.

The Parmenides System, introduced by Atkinson *et al.* in [12], was designed to overcome some of the shortfalls of the systems discussed so far in this section. It is a system designed to gather public opinion on government proposals for action. In order to achieve this, all of the action proposals within the system are structured using ar-

[2]DEMOS: http://www.demos-project.org/

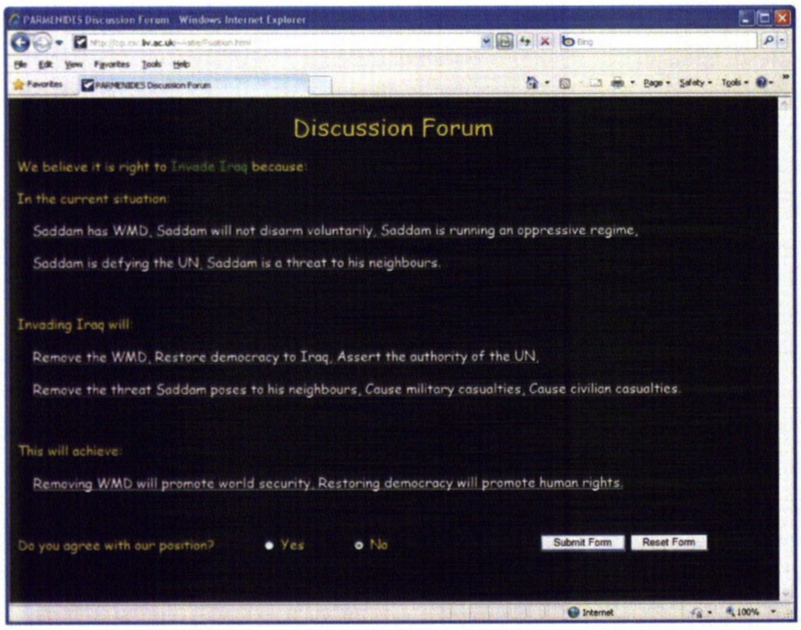


Figure 4.1: The Parmenides System Prototype - Initial Position

gumentation schemes, specifically the practical reasoning scheme described in Section 4.3.2. Feedback from citizens is achieved by posing critical questions associated with the scheme in order to precisely determine any points of disagreement. Importantly, in order to prevent confusion of users, unnecessary details of this underlying structure are hidden. Rather, the system leads users through a series of webpages in a pre-determined order, on which they simply answer "Yes" or "No" to statements representing each of the critical questions in cases where such a simple response is appropriate.

An initial prototype of the system was described in [12]. The authors use the political debate of whether Iraq should be invaded, based on the actual debate the took place concerning this issue in 2003, to illustrate the workings of the system. At the time that the prototype was created, this was a relevant debate that was receiving a large amount of media attention. A BBC News "Have Your Say" feature which was conducted in March 2003 received hundreds of responses, with a wide range of differing points of view on whether the Iraq invasion should go ahead, and reasons for or against the invasion[3]. It is this type of debate that such structured systems are useful for collecting public opinion on - debates which command a wide range of different viewpoints among citizens, and that a large majority of citizens do have an opinion to share. A screenshot of the initial prototypical system is shown in Figure 4.1[4].

[3]Source: http://news.bbc.co.uk/1/hi/talking_point/2833037.stm

[4]The original Parmenides prototype is available at http://www.csc.liv.ac.uk/~katie/Parmenides.html

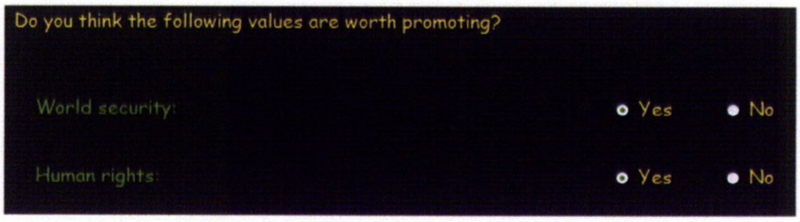


Figure 4.2: The Parmenides System Prototype - Critical Question

If the user states that he agrees with the arguments, then he exits the system. If he disagrees with any part of the arguments, then he is invited to consider the critical questions in a specific order, in order to determine exactly which part he disagrees with The first part of the website solicits "Yes" and "No" answers to critical questions which can be responded to in this way (illustrated in Figure 4.2). After this, the user goes on to provide free-text responses to questions which can not be effectively answered with "Yes" and "No".

By posing the critical questions in natural language form, and constraining responses to a simple "Yes" or "No" answer, two of the issues with previous attempts to embody formal structures in computational tools are addressed: Firstly, the user is no longer required to interact with the structure directly; he is posed survey-like questions, the style of which is likely to be familiar to most users, in order to determine their attack on the argument. Secondly, wherever possible, information submitted to the system is done so using un-ambiguous responses, i.e. "Yes" and "No", removing the possibility for the data to be interpreted incorrectly.

Although the prototypical Parmenides system was a significant development in the research areas of e-Democracy and argumentation (and the bridging of the gap between these two areas), the prototype introduced in [12] was very simple. The system consisted of a series of a PHP-based webpages which solicited opinions on the Iraq War debate, and a database to store the "Yes" or "No" responses received. There was no facility for creating other debates in the system (and indeed, no other debates had been trialed at this time), and no evaluation facilities to extract and analyse the data recorded in the database.

The Parmenides System was originally created in order to support the process of opinion gathering in e-Democracy. However, the system could conceivably be applied to other domains in which an interested party wishes to gather opinions from an audience over a proposed course of action. For example, a private company may wish to gather opinions on a proposed action from their customer base, in order to determine whether (and why) customers agree or disagree with the action. In 2007, the Mars chocolate bar company planned to use animal products in its chocolate, thus making it unsuitable for vegetarians. After this change was implemented, the company received over 6000 phone and email complaints, as well as a petition signed by forty MPs[5]. As a result of this, the company invested money and time in reverting to the vegetarian recipe.

When making a decision such as this, a company such as Mars could use Parmenides in order to gather public opinion on such a change before it is implemented. Parmenides would allow the company to put forward reasons for implementing this change (e.g. cost savings which could be passed on to customers, improved flavours), and give consumers the opportunity to make their feelings known before any time or money is invested in carrying out the change.

4.6 Summary

In this chapter, I introduced practical reasoning and discussed its history from the time of Aristotle to more recent work. I then discussed how argumentation schemes, a method of structuring arguments, can be used in relation to practical reasoning.

I went on to discuss how practical reasoning can be used to support reasoning about government policy justifications, supporting the discussion with a specific example centred around the fox hunting ban currently in place in the UK. I considered the shortfalls in the e-Petition representation of the debate - namely that users are unable to express exactly why they agree or disagree with the ban. I articulated this discussion by giving a specific example of the range of attacks that could be posed against such an argument.

I developed the fox hunting e-Petition into multiple instantiations of the practical reasoning scheme in order to demonstrate the range of structured attacks that this allows against the argument. I discussed how representing an argument using an argumentation scheme forces the proponent to consider his position carefully in order to instantiate the various components of the scheme.

Finally, I discussed previous attempts to devise computational implementations of argumentation schemes and other formal structures of argument. I identified the shortfalls of these implementations, before turning to consider Parmenides, a prototypical tool introduced by Atkinson *et al.*, which specifically aims to overcome the shortfalls of the existing tools in order to allow opinion gathering on policy justifications in e-Democracy.

Taking Parmenides as a system which appears to have significant potential as a computational software tool for use in e-Democracy, in the next chapter I will describe the ways in which I have developed the initial prototype of Parmenides into a fully-featured tool with the ability to create, gather opinions on, and analyse the results of, government policy proposals.

[5]Source: http://news.bbc.co.uk/1/hi/uk/6673549.stm

Chapter 5

Parmenides System I

5.1 Overview

In this chapter I present the Parmenides System[1], a software tool which utilises computational theories of argument structure and argument representation in order to gather public opinion on topics of debate. Parmenides uses a particular argumentation scheme for practical reasoning, as described in Chapter 4, in order to structure the collection of data from its users. Submissions to the system are then analysed in terms of Argumentation Frameworks as introduced in Section 2.1.2.

The system was presented previously as a prototype in [12], and in this chapter I discuss the development of the system into a tool to enable opinion gathering in e-Democracy.

5.2 Introduction

Parmenides is an online decision-making tool that is based upon a specific underlying model of argument. It is intended as a forum by which the government is able to present policy proposals to the public so users can submit their opinions on the justification presented for the particular policy. The justification for action is structured in such a way as to exploit a specific representation of persuasive argument based on the use of argument schemes and critical questions, as described in Chapter 4.

Parmenides was introduced by Atkinson *et al.* in [12], where it is described as a system "which allows structured argument over a proposed course of action, without requiring knowledge of the underlying argumentation theory". It was conceived as a tool to complement existing research on tools such as Zeno [60] and DEMOS [91], whilst overcoming some of the usability issues inherent in such tools. At the time [12]

[1] The Parmenides System homepage: http://www.csc.liv.ac.uk/~parmenides/

was published, the Parmenides system consisted of a website through which opinions could be gathered and a database in which responses were stored.

In this section, I will describe the extensions that I have implemented in order to develop Parmenides into a usable tool for public opinion gathering in e-Democracy. These extensions can be summarised as follows:

- **Debate creation tool** - A PHP-based tool to enable debates to be created for use within the system, without the need for any technical code to be implemented. The tool outputs the necessary website, database, and settings files.

- **Analysis tools** - A Java-based set of tools to allow analysis and evaluation of the data submitted using the Parmenides website. The application consists of two separate tools to analyse different sets of data

- **Website modifications** - I have re-coded the entire Parmenides website, implementing a consistent, easy-to-use look and feel.

Each of these extensions is described in detail, starting in Section 5.3.

Throughout the remainder of this chapter, I will make use of a particular example, named "The Speed Camera Debate", to illustrate the operation of the Parmenides software. The Speed Camera Debate, which proposes the action of deploying more speed cameras on UK roads, is a debate which encapsulates the controversy surrounding the growing number of speed cameras on UK roads. For illustrative purposes I present three justifications for carrying out this particular action, relating to three different social values promoted by the consequences of the action. As per all arguments within the Parmenides system, these justifications are based on the argumentation scheme for practical reasoning. The justifications are as follows:

1. In the current situation *there is a high death toll on UK roads*. We should *install more speed cameras*. Our goals are to *reduce the number of deaths on UK roads*. This will promote *saving lives*.

2. In the current situation *many drivers break the speed limits*. We should *install more speed cameras*. Our goals are to *reduce the number of drivers breaking the speed limits*. This will promote *law and order*.

3. In the current situation *the government makes money from fining speeders*. We should *install more speed cameras*. Our goals are to *increase government revenues*. This will promote *government wealth*.

I now show how The Speed Camera Debate, consisting of the three justifications presented above, is represented in the Parmenides system. I consider the full life cycle of the debate, from creation to the analysis of results in the remainder of this chapter.

5.3 Creating a Debate

5.3.1 Overview

In this section I discuss the creation of a debate within the Parmenides system, the challenges associated with this, and how these can be overcome with the use of an automated software tool.

As one can imagine, the process of creating a new debate to be utilised in a system such as Parmenides in no trivial task. Firstly, the system administrator must create a website that both adheres to the web standards set out by the W3C[2], as well as generating data in the correct manner for storage in the back-end database. The database itself must also be set up in a way that allows the analysis tools to read data from the database and interpret the results correctly.

The administrator not only has to contend with the issues surrounding creation of the website and database, but also those of entering the debate details correctly in order to adhere to the argumentation scheme. He must understand how to formulate the argumentation scheme, the critical questions, and the correct sequence of posing the critical questions, in order to create a debate in Parmenides.

It is due to the issues outlined above that I developed the Parmenides Debate Creator, which allows for automated creation of website and database source files according to a relatively small amount of information supplied by the debate administrator.

5.3.2 Debate Creation Interface

The Parmenides Debate Creation interface is a PHP-based series of web pages, on which the debate administrator can enter details of his position in order to create a debate within the Parmenides system. The advantage of this is that debates can be added into the system quickly and efficiently, whilst maintaining a look and feel that is not only uniform and of a high standard, but also complies with the structure imposed on debates within Parmenides.

As the Debate Creator is based on PHP-based web pages, it can be accessed from any standard browser anywhere in the world, meaning that the interface could be used remotely by a system administrator.

The system consists of a number of webpages on which different elements of both the debate itself and the technical details required to support the debate are entered.

- **Debate title and question posed** - Each debate must pose the question of whether an action should be carried out in order to comply with the argumentation scheme, for example, "Should we install more speed cameras?" or "Should we ban fox

[2]More information on the W3C standards are available at http://www.w3.org

hunting?". This action is the conclusion of the argument put forward by instantiating the scheme.

- **A pool of relevant circumstances, actions, consequences, and social values** - The debate administrator must enter a pool of circumstances, actions, consequences, and social values, that are relevant to the debate. The administrator should enter all elements that could be conceived as being relevant to the debate, as it is this pool that users must choose from if and when they instantiate their own position (described further in Section 5.4.2). The debate administrator must also construct the initial position of the debate using a subset of the elements entered here. A screenshot of the webpage on which the pool of consequences should be entered is shown in Figure 5.1.

- **Initial position of the debate** - The administrator creates the initial position by instantiating the argumentation scheme for practical reasoning. To instantiate the scheme, the user can choose from the elements entered into the relevant pool of elements. The user is guided through the order in which to select the elements and can choose them from a drop-down menu, as shown in Figure 5.2.

- **Technical details** - The administrator must provide technical details of the database that will be used to store responses. These technical details include the details of the SQL server, the username used to write to the database and the associated password.

Once the administrator has created the debate by instantiating all of the required details, the system automatically creates the website that lets the public participate in the debate, and the source files for the database in which the stored responses reside. These files can then be downloaded by the administrator and extracted to the relevant web and database host machines. The debate creator also generates the debate settings file that can be imported into the Java-based analysis tools to allow the data collected through the website to be analysed.

The Parmenides Debate Creator still requires that the user have a basic knowledge of the argumentation scheme being used in order to enter the details correctly into the creator. It is therefore to be considered as a tool for assisting the debate administrator, rather than a tool that creates debates automatically. An automated tool could possibly be developed if we were to draw upon a formal underlying model for the creation of arguments, a topic that I discuss further in Chapter 8.

5.4 The Parmenides website

The Parmenides website provides an interface for the respondent to use to submit his opinions. It is coded using HTML, PHP, and CSS, and is therefore compatible with any

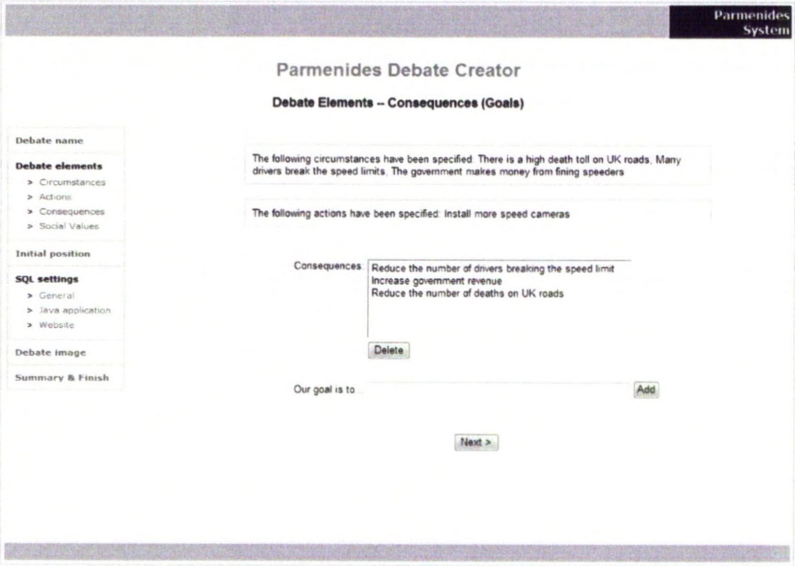


Figure 5.1: Pool of consequences in the Parmenides Debate Creator

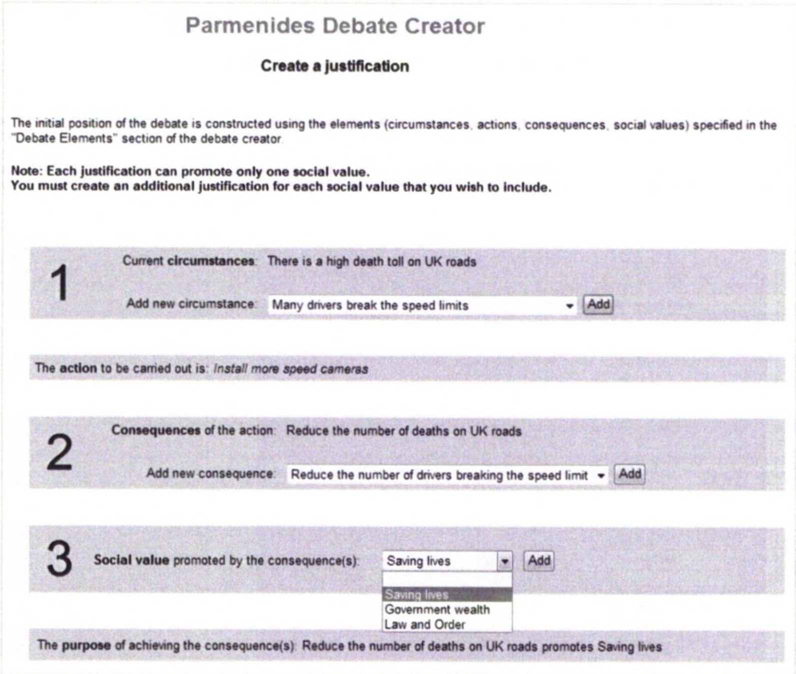


Figure 5.2: Instantiation of a position in the Parmenides Debate Creator

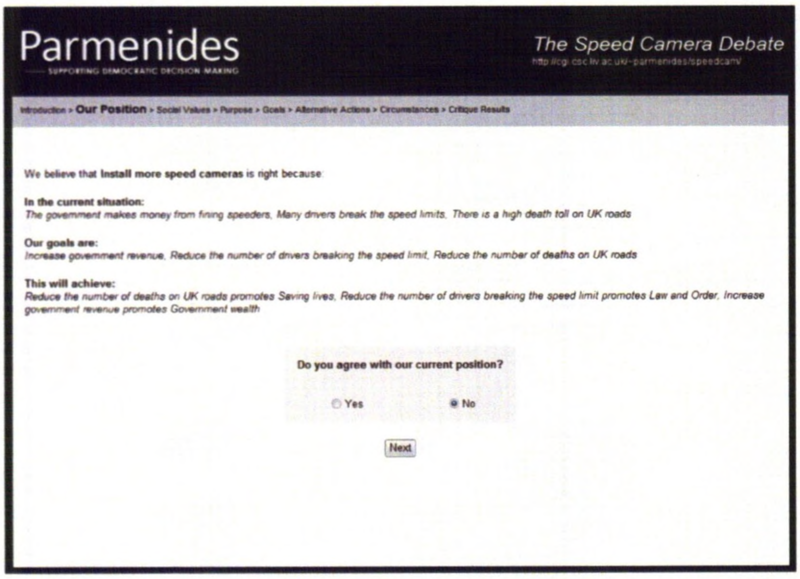


Figure 5.3: Parmenides initial position statement

standard web browser and can be accessed from anywhere in the world. All webpages used within the Parmenides system are created using output from the Debate Creator interface, which makes it easy to ensure that all pages are compatible with the relevant web standards.

I have re-developed the original Parmenides webpages, introduced in [12], with the aim of enhancing both the aesthetic and operational aspects of the website. This involved completely re-writing the underlying HTML and PHP code. On visiting the Parmenides webpage for a particular debate, the user is first given a short introduction to the purpose of the system and prompted for his name or alias. Specifically stating that the user may use an alias ensures that users who are concerned about anonymity of the system are reassured that they do not have to use their real name, as it is opinions that I am interested in soliciting from users rather than personal details. In a fielded system, issues such as multiple use and privacy concerns would need to be more fully addressed, in ways appropriate to the particular project.

The user is then presented with the position to be considered, as put forward by the government (or other argument proponent) using the practical reasoning argumentation scheme. The consequences of the action and the goal entailed by these consequences are not considered separately as per the original argumentation scheme - rather they are combined into one statement for ease of presentation to the user. The position presented to the user in The Speed Camera Debate is shown in Figure 5.3.

If the user agrees with this position, then this is recorded and he exits the system. However, if users disagree with the initial position, then they are led through a series of successive webpages on which the critical questions associated with the scheme are posed in order to determine exactly which parts of the initial position they agree and disagree with.

The original practical reasoning scheme had sixteen critical questions associated with it, as described in Section 4. A number of these critical questions are not posed within the Parmenides system for various reasons:

- **CQ12, CQ13, CQ14, CQ15:** These Critical Questions are discounted because they attack the formation of the argument itself, questioning whether the circumstances, action, and consequences are possible at all. Within Parmenides it is assumed that the states of affairs and action would only be stated if they are possible.
- **CQ3:** This Critical Question attacks the relationship between the consequences and the goal, asking whether the consequences do indeed entail the goal. As the consequences and goals are combined into one statement within Parmenides, this question becomes redundant.
- **CQ10:** This asks whether the action promotes some other social value. In itself, this question does not discredit the action being performed - rather it questions the motivation for performing the action. For that reason, it is not included in the Parmenides critique.

After this point, the Parmenides website consists of two parts: Firstly, a 'Critique' section in which the user answers Critical Questions relating the the initial position that they disagreed with. Secondly, the 'Alternative Position' section in which the user submits an alternative viewpoint on the current circumstances, the action to be performed, the consequences of this action and the values promoted by this.

5.4.1 Critiquing the Position

Critique of the initial position of the argument is achieved by considering a subset of the critical questions associated with the practical reasoning argument scheme with which the initial position is formulated. One critical question is posed to challenge each of the premises presented in the initial position of the argument. The order in which the critical questions are presented to the user also bears some importance; the user is given the opportunity to critique the circumstances first, as the user's response to this determines whether he is shown other questions which would not make sense if he had previously disagreed with the circumstance statement.

Firstly the user is invited to consider CQ1, which challenges the circumstances put forward in the initial position, as shown in Figure 5.4. In response to the critical question, the user may choose "Yes", "No", or "N/A". The N/A is selected by default on

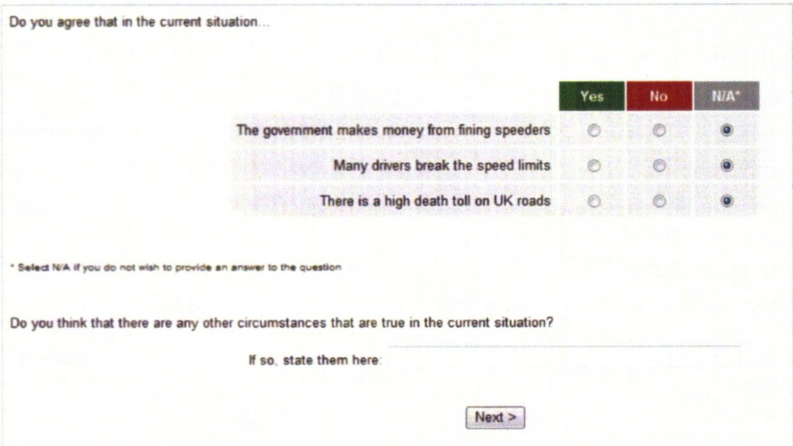


Figure 5.4: Critique of circumstances

each webpage. Its purpose is two-fold; firstly it allows the user to explicitly choose not to answer a question, and secondly it allows us to distinguish between questions that the user explicitly chose not to answer, and questions that were not answered because the user closed his browser, for example.

After submitting their agreement or disagreement with each of the circumstances, CQ16 is posed: "Is the value indeed a legitimate value?", on a webpage similar to that shown in Figure 5.4.

In the original Parmenides system, the user is taken out of the system after this page if he believes that none of the social values are worth promoting. In the updated system I allow users to continue regardless, in order to gather their opinions on the other elements of the position which may be useful in later analysis. CQ16 is posed near to the start of the critique, so that if further evaluation proved that users who did not agree with the social values should be taken out of the system, it would be relatively easy to implement this change. After submitting this page, the user is directed to the next webpage on which he is posed CQ4 in which the purposes are challenged, i.e. whether each consequence promotes the respective social value. This webpage is shown in Figure 5.5.

After critiquing the purposes, the user is asked whether the action will have any consequences which detract from each of the social values. Effectively, this is posing CQ8 to the user, which asks whether the action has a side effect which demotes the social value.

Following this the user is invited to submit his opinions, in a similar manner, on whether the goals will be achieved by carrying out the action. This poses CQ2 which questions whether the action will have the stated consequences. On this page, only purposes which do not contain premises that the user has previously disagreed with

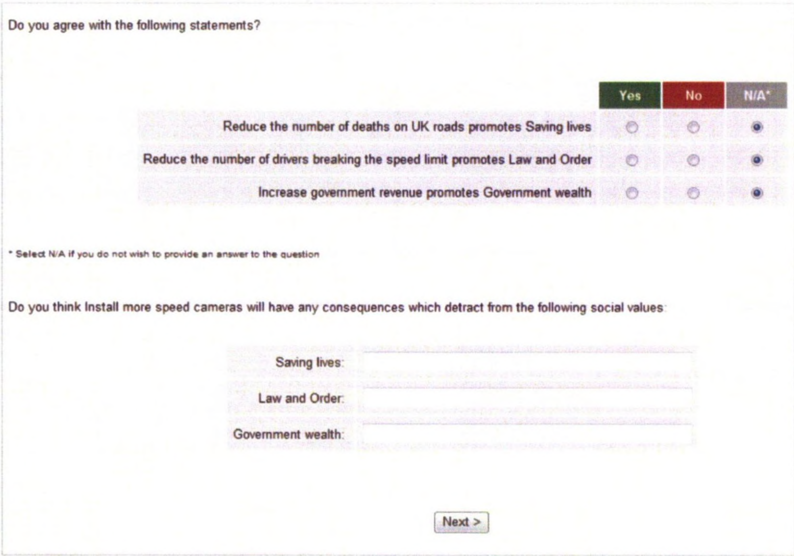


Figure 5.5: Critique of purposes

are shown. For example, if the user earlier disagreed with the fact that there is a high death toll on UK roads, he will not be asked whether installing more speed cameras will reduce the death toll. In this case, his response will be automatically recorded as "N/A" in the database.

Next the user is invited to suggest alternative actions which could be carried out in order to realise the stated consequences (this poses CQ5). On this page, shown in Figure 5.6, the user must choose alternative actions from a list. This enables more effective computational analysis of the results, as we do not have to deal with the issue of free-text responses which may be hard to analyse if received in a large volume. This issue is discussed further in Section 5.4.2. Users are also invited to submit any actions that they feel are missing from the list provided. These free text responses can be reviewed by a debate administrator in order to see whether they are candidates for being added into the pre-provided list. However, if the debate has been carefully considered by the debate administrator prior to implementation, most reasonable options should be already available to the user in the drop-down menu.

It may be argued that the administrator's full control over the only form of free-text submission within Parmenides raises an issue of bias. Whether this is an issue does, of course, depend on the domain in which the tool is eventually implemented. For example, if it is to be implemented to assist the government in refining policy proposals, then this issue is largely irrelevant as the information provided by the user is not of relevance to anyone except the administrator. In other scenarios, a more democratic approach may be desired, for example if the system was intended to gather

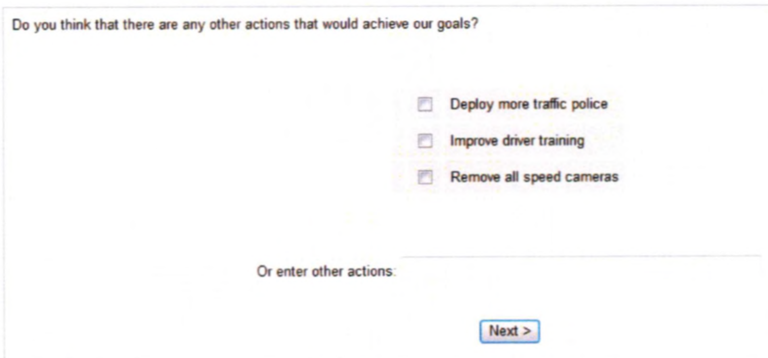


Figure 5.6: Specifying alternative actions

opinions that accurately represent public views on a particular controversial topic. In such a case, the system could be modified to allow other users to vote on which free text responses should be considered for addition to the main debate.

After submitting the alternative positions page, the user is taken to a screen on which he is presented with a summary of his views, as partially shown in Figure 5.7.

This completes the user critique of the initial position as presented by the government. The user can then optionally go on to provide an alternative position to reflect his views on the facts that are true in the current situation, and this is described in the next section.

5.4.2 Submitting an Alternative Position

After submitting his critique of the original position put forward in the debate, the user is asked whether he would like to submit an alternative position consisting of facts that are true in the current situation. If he does not wish to submit an alternative position, perhaps because he expressed agreement with most aspects of the position presented to him, or because of time constraints, then he may choose to exit the system at this point.

If the user does decide to submit an alternative position, by selecting the relevant option on the page shown in Figure 5.7, then he is firstly taken to a page which explains the process of submitting an alternative position. In order to submit an alternative position on the topic, the user must instantiate the same practical reasoning argumentation scheme that was used to present the initial position in the Critique section of the website.

To instantiate his position, the user chooses options from a drop-down menu. Although this is less expressive than allowing the user to submit free-text statements, it greatly increases the ease and accuracy with which we can computationally analyse the resulting data. For example, consider three different users, who provide three different textual descriptions of the same current circumstances:

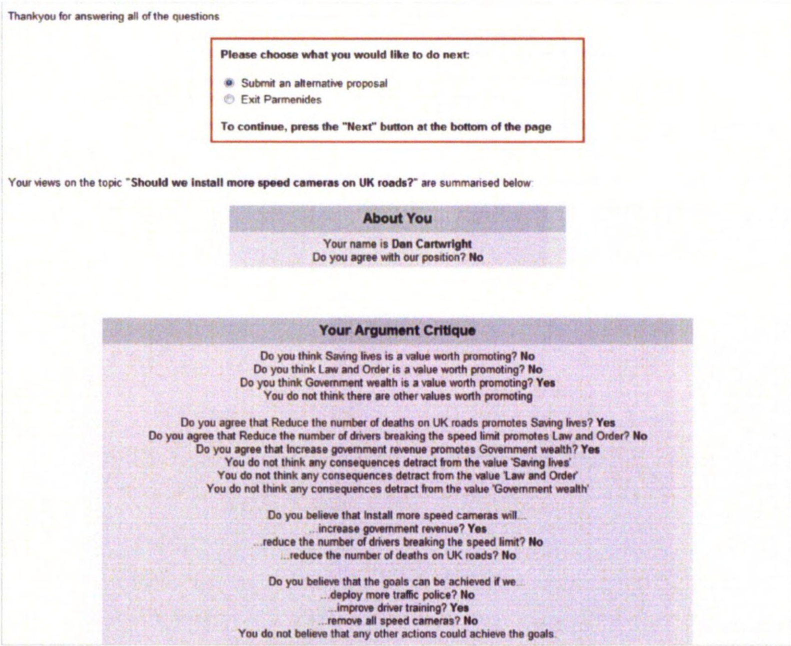


Figure 5.7: Parmenides Critique Summary screen

- User 1 - "There are not enough traffic police on UK roads"
- User 2 - "An increase in traffic police is required"
- User 3 - "There is a lack of police patrolling the roads"

As humans, we can see that these three propositions have a very similar meaning. However, the task of creating a computer software program that can make similar deductions is no trivial task. Natural Language Processing (NLP) is an area of Computer Science research which aims to develop computer software which can understand the complexities of natural language. [98] is a recent publication in the area of Natural Language processing, within which Martinez states that "parsing and understanding a natural language from an unbounded domain has proven extremely difficult because of the complexity of natural languages, word ambiguity, and difficult rules of grammar". Due to the difficulties that would undoubtedly be encountered if NLP research were to be applied to the Parmenides system, I have not considered it any further as part of my research. However, I do concede that future developments within the area of Natural Language Processing may be able to deliver significant enhancements to the Parmenides system. I discuss this further in Chapter 10.

Instead of allowing totally free text responses, I provide a trade-off within Parmenides: The user must select his position from drop-down menus, and it is this data

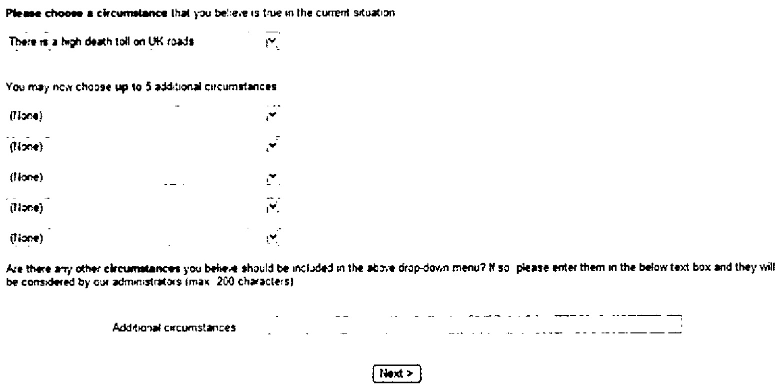


Figure 5.8: Parmenides Alternative Position - Submitting Circumstances

that is analysed by my automated software tools. If the user feels that something is missing from the drop-down menus, then he may volunteer the information in a separate free text box, which is not analysed computationally but by a human moderator. The motivation behind this is that the human moderator can consider the free text submissions and add them to the drop-down menu if she feels that the contribution is worthy. Of course, this does mean that the debate creator must carefully consider the facts relevant to the debate and make a comprehensive list of them available to the user in the drop-down menus.

After the user has read the introductory screen, he is taken to a webpage on which he is invited to choose up to six statements that most closely reflect his views of the current circumstances. Towards the bottom of the web page, the user can submit a free-text response to indicate circumstance statements that he feels are missing from the drop-down selection boxes. This is shown in Figure 5.8.

The user is then taken to a webpage on which he can choose the action that he believes should be carried out in the circumstances that he stated previously. Again, this action is chosen from a drop-down list of options, with the possibility to specify additional actions in a free-text field at the bottom of the page. The user is then prompted to choose the consequences that he believes will arise as a result of carrying out the action that he specified, and up to 6 social values which he believed will be promoted by the chosen consequence. This webpage is shown in Figure 5.9. The user can, by selecting the checkbox at the bottom of this webpage, choose to submit another consequence along with the relevant social values.

If the user elects to submit another consequence, then the webpage is loaded again. Otherwise, he is taken to the next page on which he is given the opportunity to specify additional consequences and social values for the administrator to consider for addition to the drop-down menus. Finally, the user is taken to a page on which he is shown a

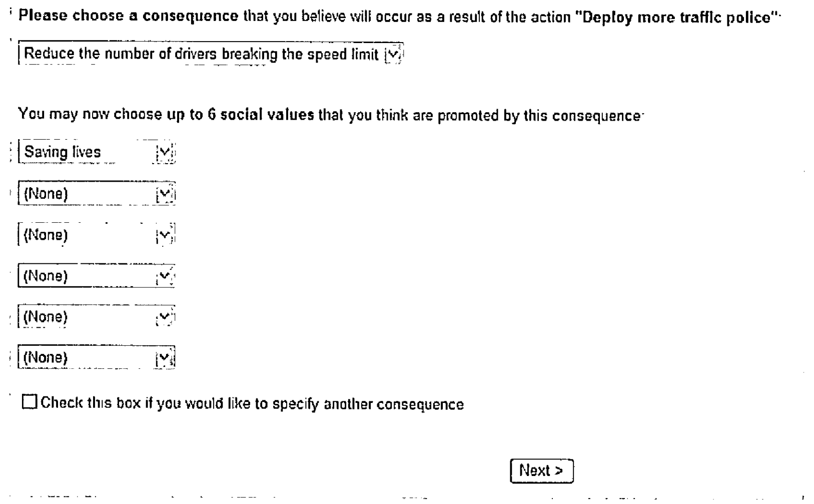


Figure 5.9: Parmenides Alternative Position - Submitting Consequences and Social Values

summary of his alternative position, as shown in Figure 5.10. It may be the case that the user believes that more than one action could be performed in the circumstances specified, in which case he can select the relevant option at the bottom of the page, and get taken back to the alternative position action submission webpage. The user is then lead through the system again from this point until he reaches the results summary page again. This process can be repeated as many times as desired, until the user has submitted all of the actions which he believes can be carried out in the circumstances that he specified.

This completes the user's interaction with the Parmenides system.

5.5 Java Analysis Tools

In order to analyse the opinion data submitted by users of the Parmenides website, a Java-based application has been implemented that analyses the arguments through the use of Argumentation Frameworks and Value-based Argumentation Frameworks, as introduced in Section 2.1.2. The application consists of two analysis tools: the 'Critique Statistics analysis tool' and the 'Alternative Position analysis tool'. Both tools retrieve user submitted opinions from the database and analyse them using Argumentation Frameworks to enable administrators to view the conclusions that can be drawn from the analysis.

The analysis tools are for use by the debate administrator and are not accessible to the public. Although I could have chosen to develop the analysis tools using an online Java applet, I decided against this for a number of reasons:

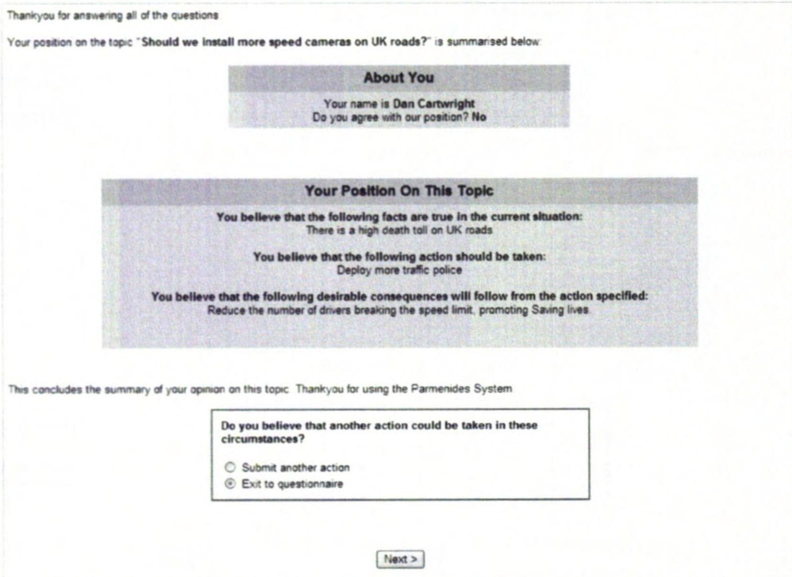


Figure 5.10: Parmenides Alternative Position - Summary Screen

- **Usability** - In order to use the tool, knowledge of Argumentation Frameworks and the way in which these should be evaluated is required. It is possible that, if the tool were made available to laypersons, it would introduce the possibility of data being mis-interpreted.

- **Confidentiality** - Although the analysis tools do not retrieve any identifying information from the database, if wide access to the results of a debate were to be permitted then it may dissuade those who are concerned about the confidentiality of their data from participating in debates.

- **Influence** - It is conceivable that allowing users to see the views of other users, could influence their own views.

Although allowing respondents to view the data collected by the system could be considered as more democratic, I decided against it in light of the possible ramifications as listed above.

When the debate administrator runs the Java-based analysis tools, she is prompted to select the debate that she wishes to analyse. After the administrator has chosen the debate that she wishes to view, the data is downloaded from the database. The administrator is then presented with a reminder of the topic of debate in the form of the initial position, as presented to the user on the Parmenides website. The screen that is displayed to the user in the case of The Speed Camera Debate is shown in Figure 5.11.

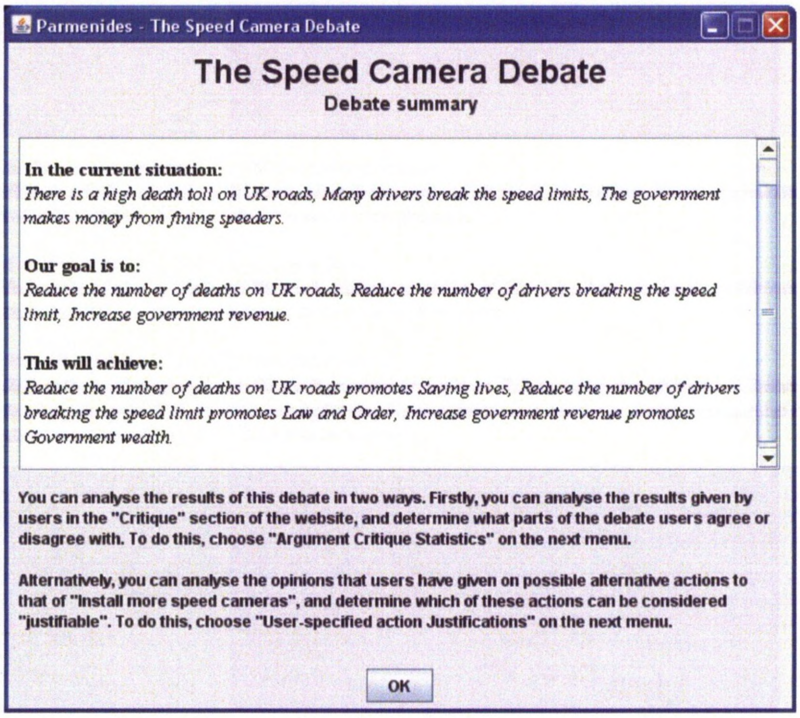


Figure 5.11: The Parmenides Analysis Tools - Debate Introduction

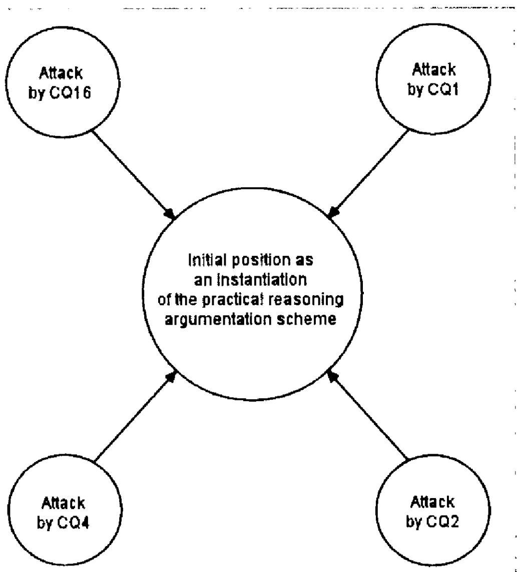


Figure 5.12: Simplified schema of how AFs are used in the Critique statistics analysis tool

Following this, the administrator can choose from the two available analysis contexts, which I describe next in turn.

5.5.1 Analysing User Critiques

The "Critique statistics analysis tool" analyses the individual critiques that users have given of the initial position of the debate and computes a set of statistics that reflect the analysis. The arguments are automatically translated into an Argumentation Framework (AF) graph representation that is displayed and annotated with the relevant statistics, allowing the administrator to easily see which element of the initial position users agree or disagree with most.

Within this tool, the initial position is broken down into a number of sub-arguments, one for each instantiation of the argumentation scheme that makes up the initial position. Each of the sub-arguments is represented as a separate Argumentation Framework, in a tabbed user interface which allows the administrator to easily compare the different frameworks. Within each AF, sub-arguments are broken down further into their constituent elements (circumstances, goals, values and purpose) according to the practical reasoning scheme on which they are based, and each element is then assigned to a node in the AF. A simplified schematic view of the way in which AFs are utilised within the Critique statistics analysis tool is given in Figure 5.12.

In the actual implementation of AFs within the Critique statistics analysis tool,

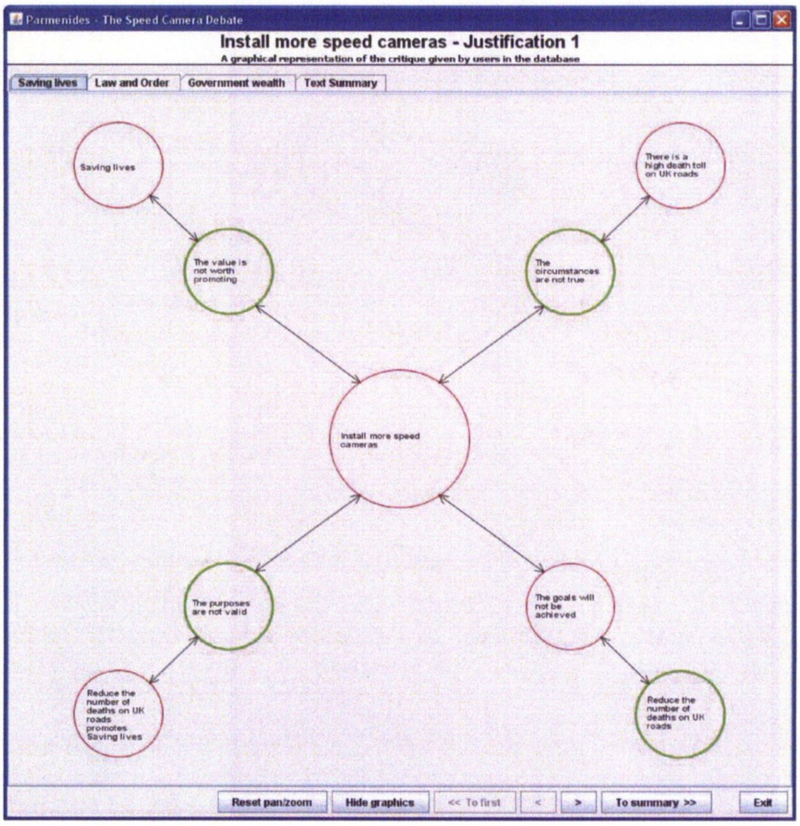


Figure 5.13: The Parmenides Critique Analysis Tool

within each branch (representing an attack by a critical question), nodes are also assigned to both the text representing the critical question, and the counter-statement of the critical question (for example "The circumstances are not as described", and "The circumstances are as described" respectively). This enables comprehensive representation of all of the possible views within the argument. For example, consider the bottom right hand branch of the AF in Figure 5.13. Here, the statement for the particular critical question under scrutiny is "Installing more speed cameras will not Reduce the number of deaths on UK roads". The counter-statement is simply its opposite: "Installing more speed cameras will reduce the number of deaths on UK roads". Through the critical questioning users are asked to say whether they agree or disagree with each positive statement, hence the need for the AF to show the opposing arguments.

In some arguments, where more than one circumstance or consequence is stated in one justification, this is indicated by an extra sub-branch within the relevant branch. By way of an example, I consider the addition of a premise to one of the justifications that comprises The Speed Camera Debate. The justification is expanded as follows:

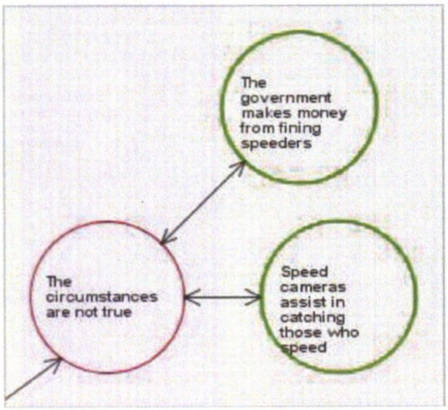


Figure 5.14: The Parmenides Critique Analysis Tool - Branch containing two circumstance statements

> In the current situation *the government makes money from fining speeders*, *speed cameras assist in catching those who speed*. We should *install more speed cameras*. Our goals are to *increase government revenues*. This will promote *government wealth*.

The expanded justification statement now has two circumstance statements, each of which must obviously be critiqued and analysed separately. A screenshot of one of the extra sub-branches within a justification framework for this particular debate is presented in Figure 5.14. In order for this particular justification to be upheld, then both circumstance statements must have majority support. For this reason, in situations where more than one circumstance and/or consequence node exist, the central node is only shown in green if *all* of the circumstance/consequence statements are green.

The critique statistics represented in the Argumentation Frameworks can be evaluated to determine the level of support for the various elements of the initial position. Defeat is determined by considering the statistics associated with each statement and its counter-statement. If more users have expressed agreement with the counterstatement for a particular element, then the node representing the positive statement for the element is said to be defeated.

The attack relations are present not only between the individual elements and their counter-statements, but also between the counter-statements and the full subargument (as represented by the central node of the AF). Therefore whenever a counterstatement has more support than its corresponding positive statement, the attack of the counter-statement on the central node succeeds and the full sub-argument is deemed to be un-justified.

In order to allow for arguments to be evaluated "at-a-glance", the Argumentation Frameworks are kept as clear and clutter-free as possible. No exact numbers are at-

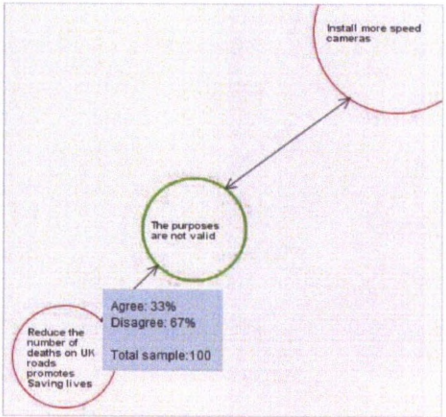


Figure 5.15: The Parmenides Critique Analysis Tool - Detailed Statistics

tached to the nodes, rather they are simply coloured green or red to denote whether most people agree with the statement represented by the node, or its counter-argument, respectively. The administrator can, however, view more detailed statistics related to a node by hovering the mouse over the particular node that she is interested in. This brings up a pop-up dialog in which the exact percentage of users that agreed and disagreed with the statement represented by the node is shown, as well as the total number of people who responded to the question. This is shown in Figure 5.15.

In addition to the frameworks for each instantiation of the argumentation scheme, the tool also provides a textual summary of the statistics, allowing the user to obtain an overview of support for various elements of the initial position. The textual summary may be a preferable form of analysis when the initial position of a debate is comprised of a large number of justifications, thus making it difficult to evaluate the numerous associated AF graphs. The textual summary, an example of which is shown in Figure 5.16, can be used to easily determine which particular element of the argument is most strongly disagreed with.

5.5.2 Analysing Alternative Positions

The second tool comprising the Parmenides Analysis Tools is the Alternative Position analysis tool. This tool evaluates alternative positions submitted using the Parmenides webpages, the process of which is described in Section 5.4.2. Alternative Positions are evaluated in terms of Value-based Argumentation Frameworks (VAFs), which I described in Section 2.1.2 as an extension to standard Argumentation Frameworks. In VAFs, arguments can be evaluated according the social values that they promote.

As with the Critique Statistics analysis tool, the Alternative Position analysis tool presents one framework for each justification that comprises the initial position of the

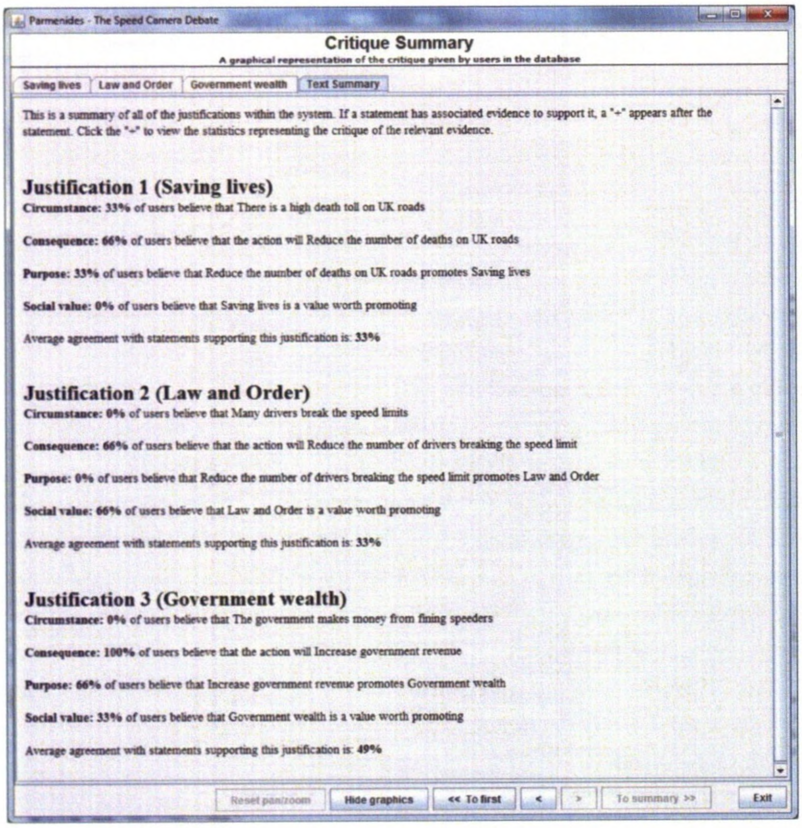


Figure 5.16: The Parmenides Critique Analysis Tool - Textual Summary

debate. However, in contrast to the Critique statistics analysis tool, the Alternative Position analysis tool does not use quantitative data in order to determine the status of the various positions within the framework.

I demonstrate the use of VAFs within the tool firstly by way of a general schema, as shown in Figure 5.17. Again, the initial position of the debate is represented in the centre of the framework. For this framework, we can disregard all elements of the positions except for the action and social value(s) that the position promotes. This is because the VAF representation only requires visibility of the conclusion of the argument and it's motivating value in order to evaluate the positions within the framework and to determine which conclusion(s) are justifiable. Surrounding the initial position is one attacking node representing each social value that has been specified by a user in an alternative position. Also attached to each node is the list of actions that users have stated as promoting the particular social value represented by the node. For example, consider a database in which the following positions have been submitted in relation to The Speed Camera Debate (again, we only need to consider the action, which is the conclusion of the argument, and the social value promoted by this action):

- Deploy more traffic police, promoting Saving lives
- Remove all speed cameras, promoting Road safety
- Improve driver training, promoting Saving lives and Driver skill

In this case, the framework would contain three nodes in addition to the nodes representing the initial position. The additional, attacking, nodes would represent the following:

- **Social value:** Saving lives - **Actions:** Deploy more traffic police, Improve driver training
- **Social value:** Road safety - **Actions:** Remove all speed cameras
- **Social value:** Driver skill - **Actions:** Improve driver training

All of the above-mentioned nodes would therefore be added as attackers to the nodes that represent the initial position.

Figure 5.18 shows the output of the alternative position analysis tool for The Speed Camera Debate. When the administrator first loads the tool, all of the nodes within the framework are black. This indicates that the administrator has not yet supplied the necessary information for evaluation of the framework to be performed, and thus we do not know which attack(s) succeed.

Within the tool, the user can navigate between the VAFs that represent the different justifications by clicking the tabs towards the top of the window. At the right of each

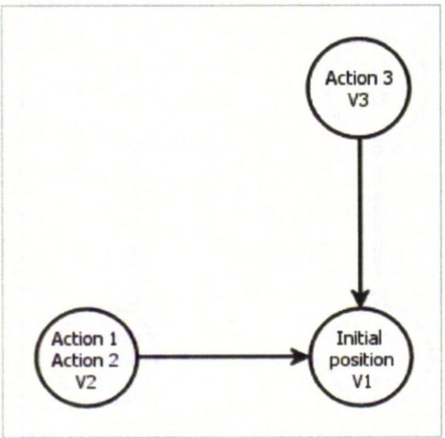


Figure 5.17: Schema showing the use of VAFs in the Parmenides Alternative Position analysis tool

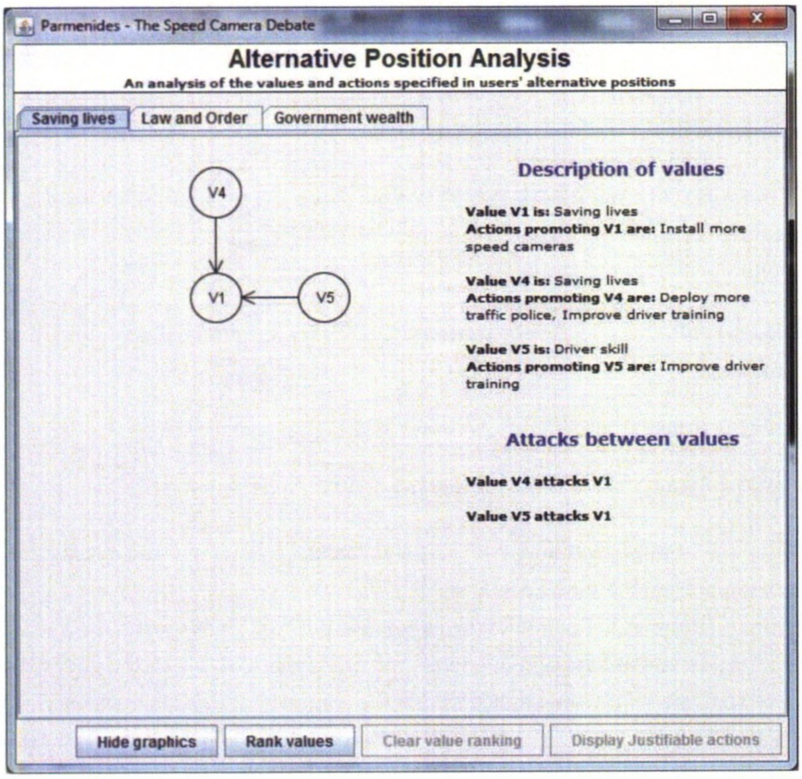


Figure 5.18: The Parmenides Alternative Position analysis tool

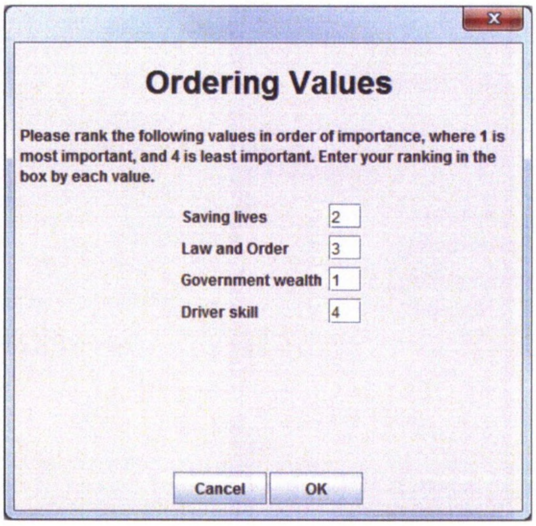


Figure 5.19: Ranking of values within the Parmenides Alternative Position analysis tool

screen is a textual summary of the information shown in the VAF. If there exists over 8 alternative positions that promote unique values, then the graphical summary is hidden from the user in favour of the textual summary, due to the difficulties of displaying a large number of nodes in the framework.

5.5.2.1 Evaluating the VAF

The Alternative position analysis tool can be used to obtain a subset of actions, from those submitted within positions that are alternative to the initial one, which can be considered "justifiable" actions to carry out. The administrator obtains the set of justifiable actions by applying a ranking over the values that appear in each VAF, as described in [20]. This ranking could be produced by a number of different means. For example, it could be a reflection of the administrator's own personal beliefs, obtained from a vote carried out on a particular audience, or provided by the government or other interested group. In order to supply the ranking of values, the administrator must click the "Rank values" button, which brings up the value ranking interface as shown in Figure 5.19.

To indicate the preference ordering of the values, the administrator simply types a number between 1 and (Number of Values) into each box, where 1 indicates the most preferred social value. Once the ranking has been provided, the arguments are evaluated as follows: if an argument attacks another whose value has a lesser ranking, the attack succeeds; if an argument attacks another whose value has a higher ranking, the attack fails; if an argument attacks another whose value is the same as that of the attacker, the attack succeeds. Once the value ranking has been applied, the VAF

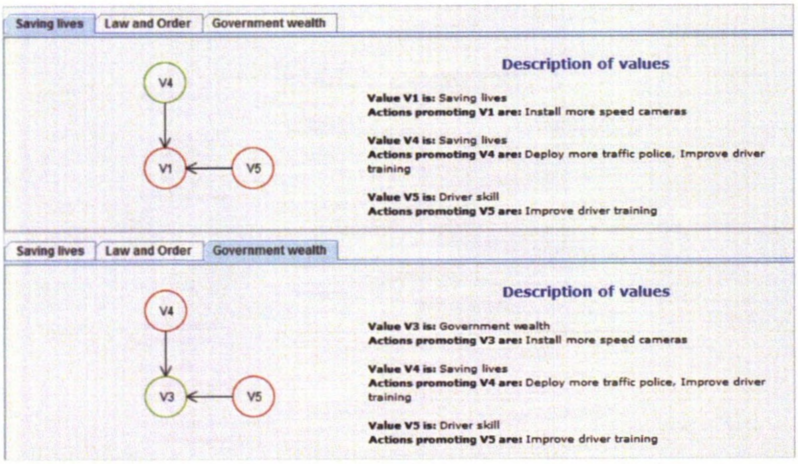


Figure 5.20: Parmenides Alternative Position analysis tool - Results of applying a value ranking to two VAFs

is updated to show the status of the arguments which have been evaluated according to the given ranking. Those arguments that are defeated have their associated nodes outlined in red and those outlined in green are not defeated. The VAFs for two of the justifications in The Speed Camera Debate are displayed in Figure 5.20, with the ranking shown in Figure 5.19 having been applied to the framework.

The actions which promote the values represented by the green nodes can then be considered 'justifiable' actions to carry out, since they withstood the critiques applied given the value ranking, and any one may be justifiably chosen to execute. The justifiable actions are computed automatically and displayed to the administrator once her value ranking has been applied to the framework. Alternatively, the administrator can click the "Display Justifiable actions" button in the analysis tools user interface to see them.

5.6 Profiler

The Parmenides Profiler is a PHP-based "Proof of concept" application, which I designed to demonstrate the capabilities of the Parmenides system to collect data from users which could later be analysed along with the responses that they submit using the system. This could be utilised in allowing the Parmenides Analysis Tools to carry out demographic profiling of responses.

The Parmenides Profiler allows users to create an account, in which they can complete a profile consisting of questions entered into the system by the administrator. Such questions could include details such as age, ethnic original, and marital status. All questions within the Profiler would be strictly optional - if the user did not wish to

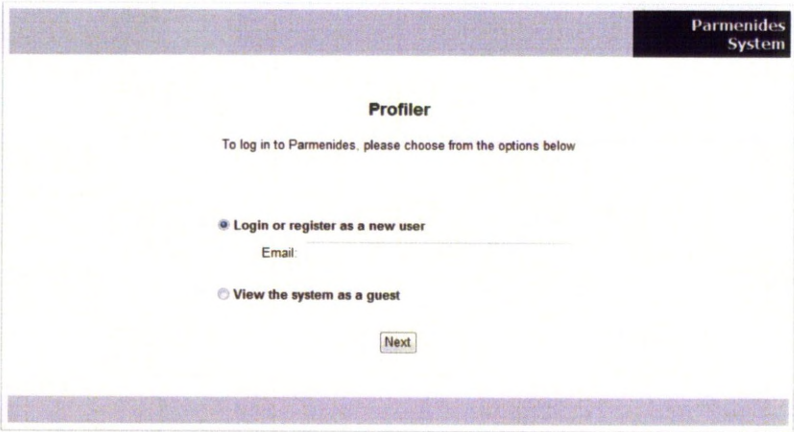


Figure 5.21: The Parmenides Profiler - Entry Screen

submit an answer to any or all of the questions, then he is not precluded from using the system. The user's profile is then linked to the opinions that he submits on any debate within Parmenides, through the use of the Parmenides relational database.

The Profiler system consists of two main components:

- **Profiler User Interface** - The web-based interface through which users can submit information about themselves for use in demographic profiling
- **Profiler Administrative Interface** - A web-based interface through which administrators can edit or remove users from the profiler, add new questions to the profiler, and make new debates available for use by Profiler's users

I now discuss each component of the Profiler in turn.

5.6.1 User Interface

In order to use the Parmenides Profiler, the user must firstly visit the Profiler website. In future, the user could be provided with a link to the Profiler system after he has finished submitting his opinions on any topic of debate. The entry page to the Profiler system is displayed in Figure 5.21.

The user is given the opportunity to either enter his email address into the Profiler, or to log in as a guest. Logging in as a guest allows the user to view the profiler without submitting any personally identifiable information, however, when the user exits the system then all data submitted is deleted.

If the user decides to enter his email address into the Profiler, then this is checked against the database of existing accounts. If an account already exists for the email address, then the user is prompted for his password. If no account exists, then the user is prompted to create a new account by choosing a password.

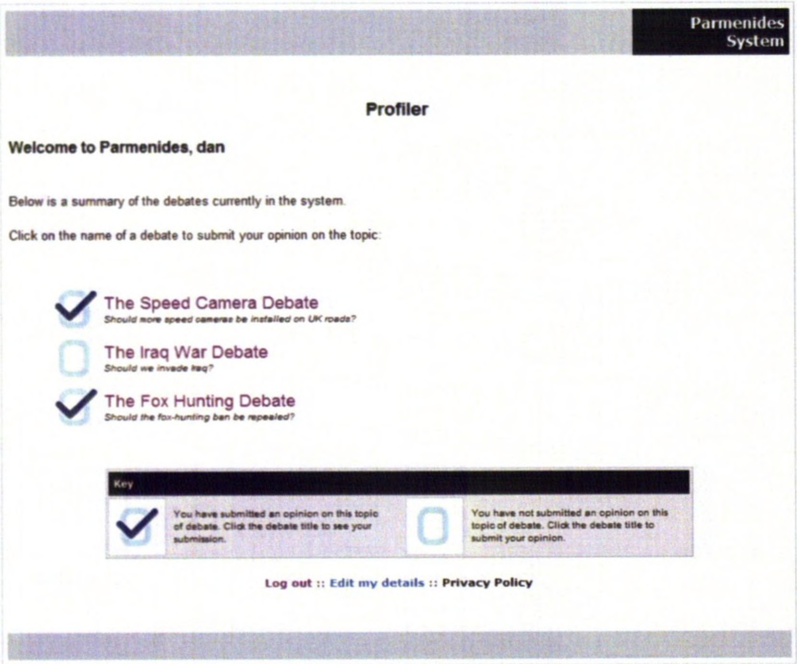


Figure 5.22: The Parmenides Profiler - Main Screen

Once the user has either logged into his existing account, or created a new account, then he is taken to the main page of the Profiler. On this page, the user can see which debates he has already participated in (whilst logged into the Profiler), and choose to participate in those debates for which no opinion has been submitted. This is achieved by simply clicking the name of the debate, following which the user is taken to the opinion submission interface for that particular debate. A screenshot of the main page of the Profiler is shown in Figure 5.22.

Where a debate is marked with a tick on the main screen, this indicates that the user has already submitted his opinion on this particular topic. By clicking the name of such debates, the user is taken to a webpage on which he is shown the dates and times of his previous submissions on this topic of debate. This screen is shown in Figure 5.23.

From here, the user can decide to view a summary of his previous submission by clicking the relevant entry, which takes him to the results screen shown in Figure 5.7. Alternatively, he can decide to submit a new critique (which will overwrite the critique already submitted in order to ensure consistency of analysis results), or to submit an alternative position to accompany his critique, if he has not already done so.

I now consider again the main screen of the profiler as per Figure 5.22. Another option available to the user aside from participating in, and viewing previous submissions to, debates within the system is for the user to submit details about himself by

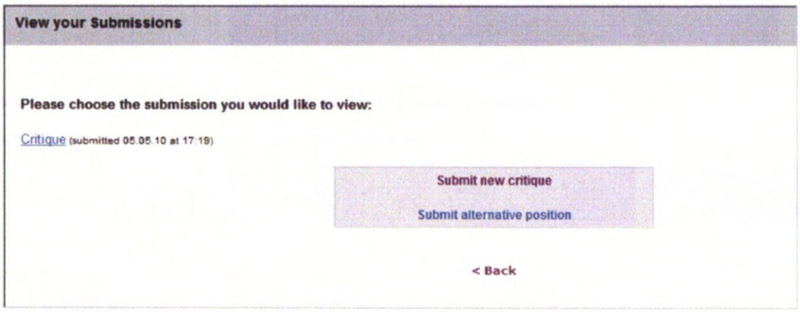


Figure 5.23: The Parmenides Profiler - Screen showing user's previous submissions on a particular topic of debate

clicking the "Edit my details" link near to the bottom of the website. This takes the user to a further webpage on which he can edit the mandatory details already collected as part of the signup process, for example name and email address, or he can provide further optional details used for demographic profiling, as shown in Figure 5.24.

Although in this particular example, only one question has been utilised within the Profiler, it is simple for the administrator to add more questions into the system using the interface described in Section 5.6.2.

Once the user has completed his interaction with the system, he can log out by clicking the "Log Out" link at the bottom of the main page. After clicking this link, the user's profile is no longer associated with any further data he may submit using the Parmenides system, unless he chooses to log in to the Profiler again.

5.6.2 Administrative Interface

The administrative interface of the Parmenides Profiler allows the system administrator to quickly and easily modify parts of the Profiler system, without any in-depth technical knowledge. Once the administrator has logged into the administrative interface, which is a PHP-based webpage similar in look and feel to the Profiler itself, she is presented with the main screen which allows her to access all of the features of the system. The administrator can perform the following tasks:

- **Add a debate** - This allows the administrator to add a Parmenides debate to the list of debates shown to users of the Profiler. The administrator needs supply only the URL to the debate and the title of the debate.

- **Edit a debate** - Allows the administrator to edit details of a debate which has already been added into the Profiler. For example, the title can be modified.

- **Edit users** - Allows the administrator to remove a user from the profiler.

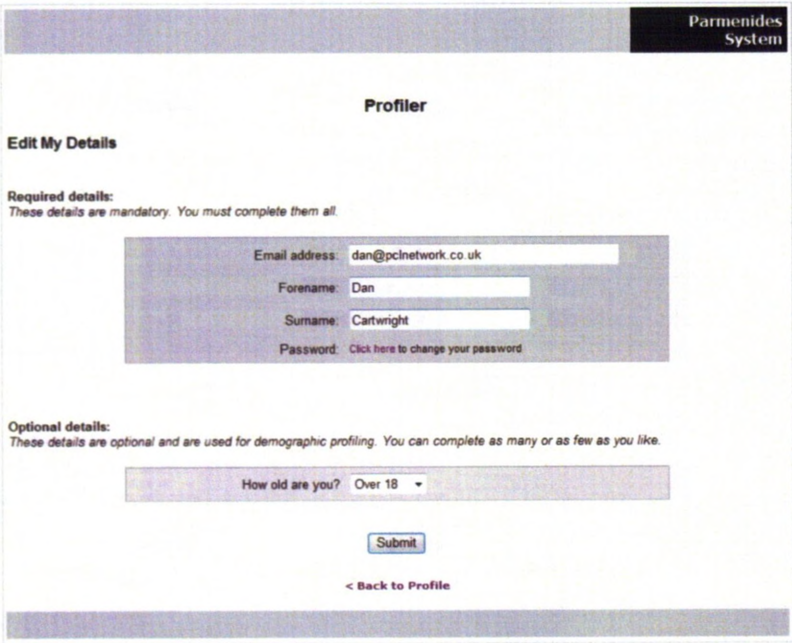


Figure 5.24: The Parmenides Profiler - Collection of information used for demographic profiling

- **Add a profiler question** - Allows the administrator to add a new question into the profiler system. The administrator can specify the question and the responses that the user can choose from.

- **Edit profiler questions** - Allows the administrator to edit questions (and possible responses) already posed within the profiler system.

I will not give any further details of adding a debate, editing a debate, editing a user, and editing profiler questions. These carry out fairly simple functions to manipulate data that exists in the Parmenides relational database. I will give a brief overview of the process of adding a new question into the profiler system in order to demonstrate the simplicity offered by the administrative interface.

In order to add a question to the profiler, the administrator firstly clicks the relevant link on the main page. This takes the administrator to the page illustrated in Figure 5.25. On this page, the administrator must specify the question, the database column which will store responses to the question, the number of alternative responses from which the user can choose, and whether or not the question is enabled. If a question is disabled, then it is stored in the system, but the question is not posed to users.

Once the administrator has completed these details, she can press "Next" in order to progress to the next webpage. Following this, a webpage appears on which the

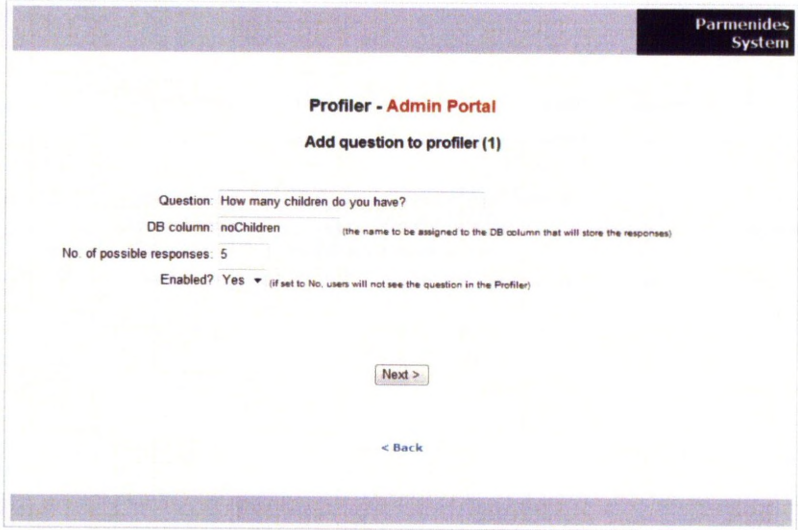


Figure 5.25: The Parmenides Profiler - Adding a question to the profiler

administrator can specify possible answers to the new question. These will be presented to the user in a drop-down menu, from which the user can choose one response. Once the administrator has entered all of the possible responses and clicked the next button, she is taken back to the main menu and the question has been successfully added into the Profiler.

As I have described in this section, the Profiler provides an add-on to the Parmenides system which enables information to be collected from users of the system which can later be used for demographic profiling of responses. The Profiler administrative interface allows administrators to quickly and easily edit the information which appears within the Profiler. Although the data that is collected is currently not used during the analysis of opinions, it would not be difficult to design tools which could make effective use of the data in demographically profiling users and the opinions that they submit using the Parmenides system.

5.7 Summary

In this chapter, I presented an introduction to the Parmenides system, which is a system designed to gather, analyse, and evaluate public opinion on a particular topic of debate. Although Parmenides is based on a particular structure of argument, namely argumentation schemes, this structure is hidden from the user in order to promote usability and expressivity.

Parmenides consists of a website through which users can submit their opinions, a database to which the resulting data is written, and a Java-based analysis tool which retrieves this information from the database and displays it according to the semantics of Argumentation Frameworks, an established method of argument visualisation and evaluation.

In Chapter 7, I return to the Parmenides system to describe some of the additional features implemented in order to support argumentation scheme interactions. Initial investigations into the interaction of argumentation scheme is described next, in Chapter 6.

Chapter 6

Responding to Critical Questions

6.1 Overview

Despite a wealth of existing research on argumentation schemes and how they can be used to represent different types of argument, there is very little in the literature regarding argumentation scheme interaction.

In this chapter, I consider how one can respond to the critical questions of an argumentation scheme by instantiating a different scheme, thus creating a supporting or attacking interaction between the two schemes. I consider a number of specific examples before attempting to generalise these examples into a general model of argument scheme interaction in terms of response to critical questions.

6.2 Motivation

In Chapter 4, I discussed the use of argumentation schemes as a method of providing structure to arguments. The critical questions associated with each argumentation scheme allow the various premises put forward in the scheme to be challenged. Later in Chapter 5, I described how I have used argumentation schemes in a specific tool to allow public opinion gathering in the domain of e-Democracy.

In both of these previous discussions, arguments have been treated as standalone entities - argumentation schemes are used to put forward arguments and critical questions can challenge various parts of the argument. No consideration is given to what happens after this point.

In the real world, however, arguments are very rarely standalone entities. We draw upon other arguments in order to support our own arguments, and to support and attack the arguments made by others. For example, consider a dialogue between a couple named Anne and David, who are considering what brand of car they should buy:

> **Anne:** I think we should buy a Volvo, because Leif Johansson, an expert in the automobile industry, claimed that they are the safest cars on the road
> **David:** I don't dispute that Leif Johannson said that, but he is biased!

It is not too difficult to imagine how the above argument could be represented in terms of an argumentation scheme - specifically the "Argument from Expert Opinion" scheme described in [166]. David's reply is an instantiation of one of the critical questions associated with the scheme. In the previous chapters, this is where our discussion of the process of argumentation stopped. However, in the real world, Anne is unlikely to concede defeat at this point, leaving two possibilities:

- Anne would respond to David's attack with an argument that supports her initial argument, thus rebutting David's attack;
- David would provide additional evidence to support his attack, thus making it more difficult for Anne to rebut the attack.

This next step of argumentation, which considers how new arguments can be created in order to support and attack existing arguments, has not been widely studied in the literature. The aim of the rest of this chapter is to develop an account of how arguments interact with each other in real world debates. I will then demonstrate how this can be developed into a formal account of how argumentation schemes interact with each other, and in the next chapter I describe extensions to the Parmenides system which enable it to utilise such interactions.

6.3 Interaction Between Argumentation Schemes

I now turn to consider how argument interactions can be represented in terms of argumentation schemes. Firstly, I refer back to the example given earlier of Anne and David's argument over which car they should purchase. This argument could easily be characterised as an instantiation of the "Argument from Expert Opinion" argumentation scheme, which is stated in [166] as follows:

> Person E is an expert in Domain D. E asserts that A is known to be true. A is within D. Therefore, A may (plausibly) be taken to be true

Anne's initial argument could be instantiated using the scheme as follows:

> Leif Johansson is an expert in the Automobile industry. Leif Johansson asserts that Volvos are the safest cars on the road. Car safety is within the

> automobile industry. Therefore, the fact that Volvos are the safest cars on the road may (plausibly) be taken to be true.

David's dispute of this argument would be instantiated using one of the critical questions associated with the argumentation scheme, specifically CQ4: *Is E personally reliable as a source?*

Obviously, a "Yes or No" answer to this question is appropriate, but in real-world argumentation one would expect an argument to be provided to support this answer. At this point, David could provide such an argument to back up his attack of Anne's position, instantiated using one of the other argumentation schemes documented in the literature. Obviously, the scheme that is chosen depends on the particular argument that the attacker has in mind. Such a decision may be influenced by a number of factors, ranging from those which are objective to those which are highly subjective.

For example, the attacker may choose his argument based on previous experience with the person who put forward the initial argument. An attacker who knows the views of a proponent, perhaps based on past interactions, will be able to tailor his argument to take into account the views of the proponent. If we consider an attacker who is aware that the proponent of the position particularly dislikes a particular expert, then the attacker is likely to avoid choosing an attacking argument which relies on the statement of this particular expert. The choice of argument may also depend on the attackers particular interests and areas of expertise - he may benefit from putting forward an argument that falls into his particular area of expertise, rather than trying to string together an argument on a topic about which he is less knowledgeable.

Finally, the argument chosen by the attacker will differ depending on the particular type of argument put forward by the proponent, and by the particular critical question chosen to challenge that argument. It is this aspect that I will study in the remainder of the chapter. I go on to provide a discussion of a practical software-based implementation of the theoretical work developed here in Chapter 7, where I extend the Parmenides system to handle multiple interacting argumentation schemes.

The first step in developing a formal account of argumentation scheme interactions is to consider some of the existing schemes available, and determine which particular argumentation scheme(s) is/are best suited to responding to each particular critical question. Of course, to do this for every argumentation scheme in the literature would be no trivial task; and so in the following chapter I discuss my approach to carrying out this investigation.

6.4 Initial Investigation: Responding to the Practical Reasoning Scheme

In light of the huge number of argumentation schemes available (in [166] alone Walton discusses 60 schemes, each of which has a number of associated critical questions), I start my account of scheme interactions by considering the practical reasoning scheme used in the Parmenides system. I will consider all of the critical questions associated with the practical reasoning scheme, and determine which other argumentation scheme(s) are most appropriate for responding to each particular question.

In order to ensure a reasonably thorough experiment, I will consider the practical reasoning scheme in relation to three particular debates that have been implemented in the Parmenides system. It is possible that the type of scheme that is most appropriate for responding to each critical question will differ depending on the particular instantiation of the scheme, and thus considering three rather different arguments will ensure a wide range of possibilities are considered.

The three debates that I will consider are as follows:

- **The Speed Camera Debate** - In the current situation *The government makes money from fining speeders, Many drivers break the speed limits, There is a high death toll on UK roads.* Therefore we should *Install more speed cameras.* Our goals are to *Increase government revenue, Reduce the number of drivers breaking the speed limit, Reduce the number of deaths on UK roads.* Reducing the number of deaths on UK roads promotes *Saving lives,* Reducing the number of drivers breaking the speed limit promotes *Law and Order,* Increasing government revenue promotes *Government wealth.*

- **The Iraq War Debate** - In the current situation *Saddam has WMD, Saddam is running an oppressive regime.* Therefore we should *Invade Iraq.* Our goals are to *Remove the WMD, Restore democracy to Iraq.* Removing WMD promotes *World Security,* Restoring democracy promotes *human rights.*

- **The Fox Hunting Debate** - In the current situation *The ban gives succour to animal rights extremists, The ban ignores the findings of a government enquiry, The ban prejudices those who enjoy hunting with dogs, Less humane methods of controlling fox population have been introduced, The ban affects the livelihoods of those who make a living from hunting.* Therefore we should *Repeal the Ban.* Our goals are to *Withdraw support for animal rights extremists, Take heed of government enquiries, Improve public perception of the government, Remove the prejudice against people who enjoy fox hunting, Prevent suffering of foxes, Reduce the need for less humane methods of fox control, Create more jobs in the countryside.* Creating more jobs in the countryside promotes *Prosperity,*

> Preventing suffering of foxes promotes *Animal welfare*, Reducing the need for less humane methods of fox control promotes *Animal welfare*, Removing the prejudice against people who enjoy fox hunting promotes *Equality*, Taking heed of government enquiries promotes *Consistency*, Improving public perception of the government promotes *Consistency*, Withdrawing support for animal rights extremists promotes *Tolerance*.

As part of my investigations I have considered all of the critical questions associated with the practical reasoning argumentation scheme as used in Parmenides, for all of the arguments listed above. The reason that I only consider the critical questions that are used within Parmenides is because the eventual aim of the investigation was to assist with an implementation in the Parmenides system.

In this thesis, I will only present a selection of critical questions in relation to the three arguments, and describe an appropriate piece of evidence that could be used to respond to the particular critical question. I will consider how one particular critical question, CQ9, can be responded to for all of the three arguments. This critical question has been chosen as it was not particularly difficult to find persuasive responding arguments, with different schemes being used between the three debates. Additionally, there is only one response to this critical question for each of the debates, which makes it easier to compare and contrast the type of argument used for each of the different debates. In addition to CQ9, I will also consider a selection of two different additional critical questions for each argument.

The remainder of this section considers responses to critical questions for each of the debates described above.

- **The Speed Camera Debate** - CQ4, CQ9, CQ11
- **The Fox Hunting Debate** - CQ1, CQ9, CQ16
- **The Iraq War Debate** - CQ4, CQ7, CQ9

I now consider each of the debates in turn, formulating an appropriate critical question response for each justification that comprises the initial position of the debate. In some cases, I refer to argumentation schemes by their "AS" reference, according to the listing of schemes given in Appendix C.

6.4.1 The Speed Camera Debate

The first debate that I considered was the speed camera debate, which, as described above, has three particular justifications which make up the initial position of the debate. Here I will describe the responses to CQ4, CQ9, and CQ11 of the argumentation scheme for each of these justifications.

CQ4: Does the goal realise the value stated?

Justification 1: Does **fewer accidents** promote **saving lives**?
Response using AS8 (Argument from correlation to cause):

There is a positive correlation between reduced accident rates and reduced deaths. Therefore reduced accident rates cause reduced deaths.

Justification 2: Does **reducing speeding drivers** promote **law and order**?
Response using AS9 (The Causal Slippery Slope Argument):

Allowing drivers to speed is up for consideration as a proposal that seems initially like something that should be bought about. According to the Scottish Government: Allowing drivers to speed would plausibly cause drivers to break other, more serious, laws. This would eventually cause a serious lack of law and order. Therefore allowing drivers to speed should not be bought about, and reducing speeding drivers will promote law and order.[1]

Justification 3: Does **fewer accidents** promote **government revenue**?
Response using AS2 (Argument from Position to Know):

Government watchdogs are in a position to know the impact of road accidents on the economy. A government watchdog asserts that road accidents cost the economy £8bn every year and fewer accidents will result in greater government revenue [2]. Therefore it is true that the aftermath of a road accident costs the economy a large amount of money and fewer accidents will result in greater government revenue.

From the particular pieces of evidence that I have chose to respond to CQ4, it emerges that a number of argumentation schemes can be used to respond to this question. I now

[1]Source: http://www.scotland.gov.uk/Publications/2003/08/17977/24939
[2]Source: http://www.guardian.co.uk/uk/2007/feb/26/transport.world

consider CQ9, a critical question which I will return to consider for all three debates. This particular question applies to the action promoted by the debate, and as all of the justifications within the debate all promote carrying out the same action, this question only needs to be considered once:

CQ9: Does doing the action have a side effect which demotes some other value?

Does **installing more speed cameras** have a side effect which demotes some other value?
Response using AS3 (Argument from Expert Opinion):

Hugh Bladon, of the Association of British Drivers pressure group, is an expert in road traffic. Hugh Bladon asserts that speed cameras cause drivers to pay less attention to the road[3]. How much attention drivers pay to the road is within the domain of road traffic. Therefore, speed cameras causing drivers to pay less attention to the road may be taken to be true. Drivers paying less attention to the road demotes road safety.

Finally I consider CQ11, which again relates to the action promoted by the debate and hence only needs to be considered once:

CQ11: Does doing the action preclude some other action which would promote some other value?

Does **installing more speed cameras** have a side effect which demotes some other value?
Response using AS6 (Practical reasoning about competing actions):

Improving road markings promotes road safety. Installing speed cameras precludes improving road markings due to budget constraints. In this scenario, road safety is more desirable than any value promoted by installing more speed cameras. Therefore, we should improve road markings instead of installing more speed cameras.

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[3]Source: http://news.bbc.co.uk/1/hi/magazine/7048645.stm

Next I will consider some of the critical questions associated with The Fox Hunting debate in order to compare and contrast possible responses to those that I have found to the critical questions for The Speed Camera Debate.

6.4.2 The Fox Hunting Debate

This particular debate consists of five separate justifications, each of which I will consider individually for the critical questions (where appropriate). For The Fox Hunting Debate, I will consider responses to CQ1, CQ9, and CQ16:

CQ1: Are the Believed Circumstances True?

Justification 1: Is it true that **the ban affects the livelihoods of those who make a living from hunting**?
Response using AS3 (Argument from Expert Opinion):

The Countryside Alliance are experts in the domain of countryside affairs. The Countryside Alliance asserts that approximately 1,000 people in the UK are directly employed and housed by fox hunting[4]. The number of people housed by fox hunting is within the domain of countryside affairs. Therefore, it may plausibly be taken to be true that 1,000 people in the UK are directly employed and housed by fox hunting.

Therefore, the ban will affect the livelihoods of the 1,000 people employed and housed by fox hunting.

Justification 2: Is it true that **less humane methods of controlling fox population have been introduced**?
Response using AS3 (Argument from Expert Opinion):

Lord Burns is an expert in the domain of fox hunting. Lord Burns asserts, in the Lord Burns Enquiry, that the ban would result in the introduction of less humane methods of fox population control. Methods of fox population control are within the domain of fox hunting. Therefore, it may plausibly be taken to be true that less humane methods of fox population control have been introduced.

[4]Source: http://news.bbc.co.uk/1/hi/uk/428201.stm

Justification 3: Is it true that **the ban prejudices those who enjoy hunting with dogs**?
Response using AS3 (Argument from Expert Opinion):

The Countryside Alliance are experts in the domain of countryside affairs. The Countryside Alliance asserts that the hunting ban is motivated by prejudice[5]. The hunting ban is within the domain of countryside affairs. Therefore, it may plausibly be taken to be true that the hunting ban is motivated by prejudice.

Justification 4: Is it true that **the ban ignores the findings of a government enquiry**?
Response using AS2 (Argument from Position to Know):

Lord Livsey of Talgarth is in a position to know whether it is true that the ban ignores the findings of the Lord Burns enquiry. Lord Livsey asserts, in a House of Lords debate on 20th April 2006, that the hunting act ignores the findings of the Lord Burns enquiry[6]. Therefore it is true that the ban ignores the findings of the Lord Burns enquiry.

Justification 5: Is it true that **the ban gives succor to animal rights extremists**?
Response using AS3 (Argument from Expert Opinion):

John Gardiner, Deputy Chief Executive of the Countryside Alliance, is an expert in countryside affairs. John Gardiner asserts that banning fox hunting promotes animal rights extremism. Animal rights extremism is within the domain of countryside affairs. Therefore, it may plausibly be taken to be true that the ban gives succor to animal rights extremists.

[5] Source: http://www.countryside-alliance.org.uk/the-alliance/our-campaigns/our-hunting-campaign
[6] Source: http://www.theyworkforyou.com/lords/?id=2006-04-20b.1168.0

Despite there being five justifications within this debate, most of the appropriate responses that I found used the "Argument from Position to Know" and "Argument from Expert Opinion" schemes (the latter of which can be considered as a more specific formulation of the former). It seems that when it comes to arguing about whether a set of circumstances are true, that the statement of an authoritative source is often an appropriate response. Next I consider CQ9:

CQ9: Does doing the action have a side effect which demotes some other value?

Does **repealing the fox hunting ban** have a side effect which demotes some other value?
Response using AS3 (Argument from Expert Opinion):

The League Against Cruel Sports (LACS) are experts in the domain of fox hunting. The LACS assert that fox hunting encourages trespassing[7]. This is within the domain of fox hunting. Therefore, it may plausibly be taken to be true that fox hunting encourages trespassing.
On the basis of this argument, it can be asserted that Trespassing demotes respect.

As per The Speed Camera Debate, the response that I found to CQ9 for The Fox Hunting Debate was from the opinion of an expert. Finally, I consider CQ16, which challenges the legitimacy of the social values promoted by the initial position of the debate:

CQ16: Is the value indeed a legitimate value?

Justification 1: Is **prosperity** a legitimate value?
Response using AS4 (Argument from Commitment):

The Government is committed to encouraging prosperity according to their 2001 election manifesto. Therefore, in this case, the government should support prosperity

[7] Source: http://www.huntinginquiry.gov.uk/evidence/league.htm

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Justification 2: Is **animal welfare** a legitimate value?
Response using AS4 (Argument from Commitment):

The Government is committed to "improving animal welfare in Britain" according to their 2001 election manifesto. Therefore, in this case, the government should support animal welfare.

Justification 3: Is **equality** a legitimate value?
Response using AS4 (Argument from Commitment):

The Government is committed to equality according to the Government Equality Act 2010. Therefore, the government should support equality.

Justification 4: Is **consistency** a legitimate value?
Response using AS5 (Argument from Popularity):

If a large majority accept that consistency is a legitimate value, then there exists a (defeasible) presumption in favour of consistency being a legitimate value. A large majority of the UK population accept that consistency in law is a legitimate value. Therefore, there exists a presumption in favour of consistency in law being a legitimate value.

Justification 5: Is **tolerance** a legitimate value?
Response using AS4 (Argument from Popularity):

If a large majority accept that tolerance is a legitimate value, then there exists a (defeasible) presumption in favour of tolerance being a legitimate value. A large majority of the UK population accept that tolerance is a legitimate value. Therefore, there exists a presumption in favour of tolerance being a legitimate value.

Interestingly, in contrast to many of the other critical questions, responding to this question did not lend itself to the use of the Position to Know class of argumentation scheme. This is perhaps because social values are more subjective than factual elements of the argument (for example, circumstance statements), and therefore responses which call on the opinions of a large majority are more natural to use.

This concludes my analysis of The Fox Hunting Debate. The final debate I consider is The Iraq War Debate.

6.4.3 The Iraq War Debate

The Iraq War Debate is one of the first debates that was formulated using Atkinson et. al.'s modified practical reasoning argumentation scheme, and was used in the initial prototype of the Parmenides System [12]. The debate consists of two justifications for invading Iraq, and in this section I consider possible responses to CQ4, CQ7, and CQ9:

CQ4: Does the goal realise the value stated?

Justification 1: Does **removing the WMD** promote **world security**?
Response using AS2 (Argument from Position to Know):

Colin Powell, the US Secretary of State, is in a position to know whether removing the WMD will promote World Security. Colin Powell states that removing the WMD will promote World Security[8]. Therefore it is true that removing the WMD will promote World Security.

Justification 2: Does **restoring democracy to Iraq** promote **human rights?**

Response using AS5 (Argument from Popularity):

[8]Source: http://www.whitehouse.gov/news/releases/2003/02/20030205-1.html

If a large majority accept it as true that democracies promote human rights, then there exists a presumption in favour of democracies promoting human rights. A large majority accept it as true that democracies promote human rights. Therefore, there exists a presumption in favour of democracies promoting human rights. Democracies promote human rights, therefore restoring democracy to Iraq promotes human rights.

As per the responses to CQ4 in The Fox Hunting Debate, we see that the Argument from Popularity can be used to respond to this question. Although the Argument from Position to Know is used to respond in this case, it seems logical that it does not have as wide an application as it may do for other critical questions. Only certain expert sources will be considered to be in a position to know whether a social value is held desirable by some group, for example the government. Next I consider CQ7, which questions whether alternative actions could be carried out:

CQ7: Are there alternative ways of promoting the same value?

Justification 1: Are there alternative ways of promoting **world security**?
Response using AS3 (Argument from Expert Opinion):

University researchers are experts in the domain of UN arms embargoes. University researchers have asserted, in a report on UN arms embargoes, that the arms embargo in Iraq was successful in reducing the number of weapons available to Iraq[9]. The success of the Iraq arms embargo is within the domain of UN arms embargoes. Therefore, it may plausibly be taken to be true that the arms embargo in Iraq was successful in reducing the number of weapons available to Iraq.

Reducing the number of weapons available to Iraq promotes world security. Therefore, we should reduce the number of weapons available to Iraq.

Justification 2: Are there alternative ways of promoting **human rights**?
Response using AS3 (Argument from Expert Opinion):

[9]Source: http://news.bbc.co.uk/1/hi/7114323.stm

Researchers from London School of Hygiene and Tropical Medicine (LSHTM) are experts in death rate statistics in Iraq. Researchers from LSHTM assert that childhood mortality in Iraq declined after the Oil-For-Food program was introduced[10]. Childhood mortality is within the domain of death rate statistics. Therefore, it may plausibly be taken to be true that childhood mortality in Iraq declined after the Oil-For-Food program was introduced.

Reducing childhood mortality promotes human rights. Therefore, we should introduce an Oil-For-Food program.

The Argument from Expert Opinion scheme again seems to provide the kind of structure and level of persuasiveness needed to respond to this critical question. The final critical question that I consider for The Speed Camera Debate is CQ9, as previously considered for The Speed Camera Debate and The Fox Hunting Debate:

CQ9: Does doing the action have a side effect which demotes some other value?

Does **invading Iraq** have a side effect which demotes some other value? Response using AS11 (Argument from Cause to Effect):

Generally, if there is war in an oil-producing country then the price of oil will increase. In this case, a war in Iraq will occur. Therefore, in this case, the price of oil will rise. The price of oil rising demotes economic stability.

In contrast to The Speed Camera Debate and The Fox Hunting Debate, the response to CQ9 for The Iraq War Debate uses a different argumentation scheme. As the scheme used here, Argument from Cause to Effect, does not state the particular source of the evidence, it could be argued that this is less persuasive than source-based schemes such as Argument from Position to Know.

6.4.4 Summary of Initial Investigation

My initial investigation has allowed me to consider possible responses to a selection of critical questions of the practical reasoning argument scheme in terms of three example

[10]Source: http://www.thelancet.com/journals/lancet/article/PIIS0140673600022893/abstract

debates instantiated using the scheme. The complete investigation considered all of the critical questions of the scheme, although only some are included here in order to outline the investigation and set a foundation for the rest of the chapter.

The results of the initial investigation show that, in many cases, a particular scheme is often the most appropriate for responding to a particular critical question, regardless of the particular instantiation of the scheme. The investigation also demonstrated that some schemes are used more often than others, particularly expert source based schemes such as Argument from Position to Know. This is perhaps because such expert statements are fairly easy to come across by a simple search on the Internet or within the relevant literature, and also because the evidence of an expert tends to be considered more persuasive than evidence which does not come from an identified source.

A summary of my findings is shown in Table 6.1, where S represents The Speed Camera Debate, F represents The Fox Hunting Debate, and I represents The Iraq War Debate.

The next step of my investigation into critical question responses is to generalise the findings of my initial investigation. I will consider which argumentation schemes can be used to respond to each critical question of the practical reasoning scheme, and provide justifications of which schemes could be considered the most persuasive in responding to the question.

	CQ1	**CQ2**	**CQ4**	**CQ5**	**CQ7**	**CQ8**	**CQ9**	**CQ11**	**CQ16**
AS2	S F I	S F I	S F I	S F	S F	S F I			I
AS3	F	F	F	S I	I	S F	S F		
AS4									S F
AS5			I			F			S F I
AS6								S F I	
AS7		S							
AS8			S						
AS9			S						
AS10									
AS11							I		

Table 6.1: Summary of Critical Question Responses

6.5 Further Investigation: Generalising Critical Question Responses

In this section, I will attempt to generalise the findings presented in Section 6.4. I will consider each critical question of the practical reasoning argumentation scheme, from the subset of critical questions used in the Parmenides system as listed in Section 5.4.

For each question, I will consider which argumentation schemes seem to be the most appropriate for providing an argument in response to the question, with some discussion as to why the scheme or set of schemes is/are most appropriate. I identify the schemes that were most commonly used to respond to the particular critical question when considered in terms of specific arguments in Section 6.4. I will go on to discuss which argumentation scheme I consider would be the most persuasive in responding to the question, as it is not necessarily the case that one particular scheme will be the most persuasive for responding to all questions. Indeed, it may be the case that a scheme that is particularly unpersuasive in responding to one critical question, is most persuasive in responding to another.

Of course, the persuasiveness of a particular argument is dependent on the audience to whom the argument is presented as well as the formulation of the argument itself.

In this section, I attempt to present an objective view of persuasiveness based on the formulation of the critical question and the type of response possible using each argumentation scheme. I discuss this issue further in the conclusions of this chapter (Section 6.6).

In the remainder of this section, I abbreviate the names of the argumentation schemes according to Table 6.2.

Appendix C	Full scheme name	Abbrev.
AS2	Argument from Expert Opinion	EO
AS3	Argument from Position to Know	PTK
AS4	Argument from Commitment	AC
AS5	Argument from Popularity	AP
AS6	Practical Reasoning about Competing Actions	PRCA
AS7	Argument from Consequences based on Statistics	ACBS
AS8	Argument from Correlation to Cause	ACC
AS9	The Causal Slippery Slope Argument	CSSA
AS10	Argument from Verbal Classification	AVC
AS11	Argument from Cause to Effect	ACE

Table 6.2: Table of Argumentation Scheme Abbreviations

6.5.1 CQ1: "Are the believed circumstances true?"

The argument scheme needs to be used to provide evidence of a set of circumstances being true. In such cases, it seems to be both relatively easy and persuasive to cite the evidence given by some person or authoritative source that is in a position to know the information. CQ1 is an easy critical question to respond to - one simply needs to find a source for the set of facts that compose the circumstance statement.

- **Most commonly used scheme:** EO
- **Most persuasive scheme**: EO/PTK
- **Other possible schemes**: AP, ACC, AVC

I have listed EO and PTK as the most persuasive schemes here, as they identify the source of the information. In a situation in which solid facts such as a set of circumstances need to be supported or denied, one clearly needs to identify the source so that the respondent is convinced, or otherwise, that the argument comes from a reputable source.

Although AP, ACC, AVC were not used in the example debates that I considered, they seem like reasonable alternatives in some situations; AP, for example, can be used in situations were the opinion of a majority provides significant support for the statement (for example, in a situation where the circumstances are that "Most people disagree with euthanasia"). ACC is useful in situations where the circumstances claim some causal theory, and AS10 could be used in situations where the classification of a particular item is claimed (e.g. "Cars pollute the environment", in which cars are classified as environment pollutants).

6.5.2 CQ2: "Assuming the Circumstances, Does the Action Have the Stated Consequences?"

In this case, the argument scheme needs to provide evidence of a particular action leading to a particular state. Again, EO and PTK are the most persuasive schemes used to answer this question. EO is possibly slightly more persuasive, although more difficult to find relevant evidence to instantiate it with. ACBS is also a persuasive scheme, though it is often difficult to find relevant statistical information, especially where there are no previous cases of the action being carried out in the circumstances. Often, statistical evidence is interpreted and presented by an expert anyway and therefore the EO or PTK scheme would be used to present such evidence.

- **Most commonly used scheme:** EO
- **Most persuasive scheme**: EO/PTK/ACBS
- **Other possible schemes**: AP, ACC, ACE

AP could also be used to respond in situations in which the consequences involve the actions of a large majority (e.g. "Legalising euthanasia would result in mass rioting"). In situations where the consequences did not relate to the actions of a majority, this scheme is unlikely to be persuasive at all. ACC is also an obvious scheme to use in response to CQ2, although it does not provide the same degree of persuasiveness as, for example, EO as it does not cite sources.

6.5.3 CQ4: "Does the Goal Realise the Value Stated?"

Unlike many of the other critical questions, AP provides a persuasive argument here as social values are often subjective and therefore the opinion of a majority is important. However, as EO specifically cites the source of the argument, it may be that its use is more persuasive in some cases.

- **Most commonly used scheme:** EO
- **Most persuasive scheme**: AP/EO
- **Other possible schemes**: ACC, CSSA

ACC and CSSA were used to respond to this critical question in The Speed Camera Debate, although the arguments provided by these schemes do not seem as persuasive as others. ACC, for example, can be used in cases where the goal has a correlation with the demotion or promotion of the particular social value. However, as the scheme does not cite the source of the argument, the use of the scheme is unlikely to be preferable over other schemes.

6.5.4 CQ5: "Are There Alternative Ways of Realising the Same Consequences?"

This question is rather similar to CQ2, as both consider the consequences of performing particular actions. The opinion of an expert seems to be a highly persuasive scheme when describing an alternative action to achieve the consequences, providing, of course, that the expert is chosen wisely. This is because an expert is presumed to have an in-depth knowledge of the subject area.

- **Most commonly used scheme:** EO
- **Most persuasive scheme**: EO/PTK
- **Other possible schemes**: ACC, CSSA, AP, PRCA

AP and PRCA have been noted as usable, however they are fairly unpersuasive in most cases: AP is for representing arguments from popularity, and in most cases the opinion of a majority is not likely to provide persuasive licencing of an alternative action. Certainly, it is unlikely to be as persuasive as a carefully chosen expert in the relevant domain.

PRCA may be useful in scenarios where the alternative action promotes a social value that is particularly desirable - however, as values are always subjective, this seems unlikely to be the preferred scheme in the majority of cases.

6.5.5 CQ7: "Are There Alternative Ways of Promoting the Same Value?"

This question is similar to CQ5, in that it too is soliciting alternative actions. The questions differ slightly as this question is related to value promotion. The PTK argumentation scheme is again fairly persuasive in answering this question, although the subjectivity of social values should be taken into account when choosing a relevant expert source.

- **Most commonly used scheme:** EO
- **Most persuasive scheme**: PTK
- **Other possible schemes**: AP

AP is somewhat more persuasive in responding to this particular question than it was to CQ5. This is due to the subjectivity of values - and thus an argument which promotes a particular value on the strength of the agreement of a majority may be considered more persuasive than an argument which promotes a value on the strength of the testament of a single expert.

6.5.6 CQ8: "Does Doing the Action Have a Side Effect which Demotes the Value?"

EO and PTK are both persuasive schemes to use in answering this critical question. The opinion of an expert is likely to be persuasive in this case, as it is this type of source that is most likely to be aware of any side effects of carrying out the action. On the other hand, the question again relates to the demotion of values, and as such the subjectivity of these values needs to be taken into account when deciding on the most appropriate argument scheme, and instantiating these schemes with relevant arguments.

- **Most commonly used scheme:** EO
- **Most persuasive scheme**: EO/PTK
- **Other possible schemes**: AP, ACC, CSSA, ACE

I have identified AP, ACC, CSSA, and ACE as also being appropriate in responding to the scheme. AP is useful for representing arguments which call on the opinions of a majority with respect to value demotion. However, it seems reasonable to suggest that the opinion of a majority is probably not a particularly persuasive argument in favour of a side effect occurring as a result of the action, and hence this scheme is not likely to be favoured over schemes such as EO and PTK.

ACC could be used to argue a correlation between the action and its side effect, although it does not allow for explicit representation of value demotion. CSSA is also well suited to responding to the critical question by arguing that a "slippery slope" relationship exists between the action and the side effect of the action. However, the scheme does not state the source of the argument and hence a direct expert statement may be more persuasive.

Finally, ACE could be used to respond to the question by arguing that the action causes a bad side effect. Again, EO and PTK could be considered more persuasive as they allow for explicit representation of the expert source of information.

6.5.7 CQ9: "Does Doing the Action Have a Side Effect which Demotes Some Other Value?"

This question is very similar to CQ8, this time questioning whether other values are demoted rather than the values stated in the position put forward in the argument itself. Thus, the critical question usage is as per CQ8.

- **Most commonly used scheme:** EO
- **Most persuasive scheme**: EO/PTK
- **Other possible schemes**: AP, ACC, CSSA, ACE

6.5.8 CQ11: "Does Doing the Action Preclude Some Other Action Which Would Promote Some Other Value?"

The PRCA argumentation scheme is one that I created specifically to respond to this critical question. Although other argumentation schemes taken from the literature can be used to respond to this critical question, the complex nature of the question makes this difficult. The PRCA argumentation scheme ensures that all of the premises required in a response to the question are comprehensively supplied, and can all be individually called into question by considered the critical questions associated with the scheme. For this reason, I consider this scheme as almost always the most persuasive scheme to use. Sometimes, where a particularly persuasive expert opinion exists, it may be more appropriate to use that scheme.

- **Most commonly used scheme:** PRCA
- **Most persuasive scheme**: PTK/PRCA
- **Other possible schemes**: EO, AP

AP is listed as a possible scheme that may be used in response to this question. This is, again, due to the persuasiveness of a large population when arguing about value promotion. This scheme, however, is not able to represent the type of complex response that may be required for this critical question, and hence is unlikely to match the persuasiveness of PRCA.

6.5.9 CQ16: "Is the Value Indeed a Legitimate Value?"

The AC argumentation scheme could be used here to provide evidence of commitment to a particular social value from a government manifesto or other similar document. EO/PTK do not appear to be as persuasive as they are with other critical questions, as an expert is not necessarily in a position to say whether a value is legitimate or not.

- **Most commonly used scheme:** AC
- **Most persuasive scheme**: AC/AP
- **Other possible schemes**: PTK, AVC

AS10 allows for arguments to be made based on verbal classifications. For example, it could be used to state that if a social value has a particular property, then it also has the property that it is legitimate.

6.5.10 Summary

In this section, I have considered the specific argument responses that I generated in Section 6.4 in order to develop an initial model of how critical questions can be responded to using other argumentation schemes. I have considered the formulation of the critical questions, and the nature of the argumentation schemes and the type of premise they provide, to discuss which particular argumentation schemes could be considered to provide the most persuasive (or appropriate) argument for supporting or challenging each critical question.

In Table 6.3, I present an overview of the information presented in this section. Where an argumentation scheme is deemed as most persuasive for responding to a particular critical question, the cell is marked with a double tick (✓✓). Where the argumentation scheme is an alternative response to the critical question, it is marked with a single tick (✓).

6.6 Conclusions

In this chapter, I have considered responses to the critical questions related to the Practical Reasoning argumentation scheme. Although this only represents a small number of critical questions, I have favoured a thorough investigation of a small number of

	CQ1	CQ2	CQ4	CQ5	CQ7	CQ8	CQ9	CQ11	CQ16
AS2/EO	✓✓	✓✓	✓✓	✓	✓	✓✓	✓✓	✓	
AS3/PTK	✓✓	✓✓		✓✓	✓✓	✓✓	✓✓	✓✓	✓
AS4/AC									✓✓
AS5/AP	✓	✓	✓✓	✓	✓		✓	✓	✓✓
AS6/PRCA				✓	✓			✓✓	
AS7/ACBS		✓✓							
AS8/ACC	✓	✓				✓	✓		
AS9/CSSA						✓			
AS10/AVC	✓								✓
AS1✓/ACE		✓				✓	✓		

Table 6.3: Generalisation of Critical Question Responses

questions over a more general investigation of a large number of questions associated with a number of schemes. It is this in-depth investigation that is notably absent from previous literature on argumentation schemes. This may in part be due to it being a rather difficult and subjective task, but my investigation takes steps towards shedding some light on how such a task can be methodically approached.

In order to constrain the large number of schemes available in the literature, I chose a subset of these schemes to use in my investigations. This subset of schemes encompassed the main categories of schemes available - including schemes to support argument from an expert source, argument from cause, argument from statistics and argument from popularity.

One of the most significant findings of this work has been the wide application of the expert source schemes - namely Argument from Expert Opinion and Argument from Position to Know, to almost all of the critical questions associated with the practical reasoning argumentation scheme. It seems that arguments which are based on facts from explicitly specified sources, where these sources are known to be experts in the relevant domain, tend to be highly applicable and largely persuasive in a wide range of scenarios. Another reason for the persuasiveness of these schemes could be that it is assumed that the expert has done some reasoning before he makes his assertion - that is, he has weighed up all of the evidence available before making his assertion.

In contrast, in scenarios where we are arguing about more subjective propositions, for example the legitimacy of a social value, a different set of argumentation schemes becomes appropriate. In this case, the opinion of a single expert may not be as persuasive as the opinion of a large majority of people. This is because an expert is not necessarily in a position to assert that a social value is legitimate, unless the expert source is chosen with great care (for example, a government may be in a position to defend the legitimacy of a particular value). To respond to these kinds of critical question, we are interested more in opinion rather than technical facts, and to provide some kind of licence for this opinion it must be one held by a "large majority".

From this discussion, one could conclude that there are a number of different categorisations of critical question, included in which are the following:

- Questions which are technical in nature, whether of fact or relying on a theory, which are often well responded to by statements of specialists (experts, record keepers, authorities, etc.).
- Questions which reflect the mood of an audience, often questioning whether subjective facts are true ("Is the death toll too high?", "Is it important to keep taxes low?"). This type of question is often best responded to by appealing to the thoughts and feelings of a population, or results of an opinion poll, or the opinion of a non-expert (the press, or a popular spokesperson, for example).
- Questions of political choice, for which arguments from commitment are most often appropriate (for example, manifesto statements or a statement made by the Prime Minister).

It is possible that further types could be identified, or that these types could be either broadened or further refined, if critical questions of other argumentation schemes were to be considered.

In Section 6.4, I considered specific instantiations of the practical reasoning argumentation scheme and specific instantiations of responses to the critical questions of the scheme. It is interesting to note that in some cases, the conclusion of the responding argument scheme is not necessarily precisely the same (in cases of support) or precisely the opposite (in cases of rebuttal) of the premise that is being responded to. For example, consider the following partial instantiation of the practical reasoning scheme:

> *The ban affects the livelihoods of those who make a living from hunting*

And the associated critical question:

> *Is it true that **the ban affects the livelihoods of those who make a living from hunting**?*

As per the investigation in Section 6.4, this question can be responded to using evidence from Expert Opinion argumentation scheme as follows:

> The Countryside Alliance are experts in the domain of countryside affairs. The Countryside Alliance asserts that approximately 1,000 people in the UK are directly employed and housed by fox hunting. The number of people housed by fox hunting is within the domain of countryside affairs. Therefore, it may plausibly be taken to be true that 1,000 people in the UK are directly employed and housed by fox hunting.

We can see that although this argument does not provide a direct response to the question, it does justify a response to the question. In order for the argument to be a valid reply, a further entailment statement must be added:

> *Therefore, the ban will affect the livelihoods of the 1,000 people employed and housed by fox hunting.*

It is natural to add this entailment statement without too much thought in real-world human arguments; however it must be taken into consideration when designing a computational system to support argument scheme interactions. It is critical to note and address the fact that none of the critical questions associated with the argumentation scheme will provide the opportunity to critique this entailment statement. I consider this further in my implementation of argumentation scheme interactions in Chapter 7.

To conclude this chapter, I make one final remark: Much of the work carried out in this section has required judgment to be made into both the appropriateness and persuasiveness of arguments. I concede that although I have been as objective as possible and supported my statements with justifications, such investigations are likely to be somewhat subjective, and therefore more research and end-user evaluation would help to verify, fine-tune, and ultimately expand the findings of this work.

6.7 Summary

In this chapter, I have investigated how argumentation schemes can support and attack the premises of other arguments by responding to critical questions. This follows from a real-world consideration of arguments; when we respond to an argument put forward by another person, we rarely simply answer "Yes" or "No". Rather, the response to such an argument is normally another argument intended to support or attack the argument of the proponent.

I firstly discussed three example debates instantiated using the practical reasoning argumentation scheme. I considered each of the critical questions associated with the scheme, and developed an argument, instantiated using a different argumentation scheme, to respond to each question.

I then went on to discuss a more general theory of argumentation scheme interaction. I considered each of the critical questions associated with the practical reasoning scheme and, based on the results obtained in the first part of my investigation, determined which argumentation schemes seemed most appropriate and most persuasive in responding to each of the questions.

In Chapter 7, I will discuss a software implementation of the theories developed in this chapter in the form of extensions to the Parmenides system. These extensions will allow the system to deal with multiple, interacting arguments. In Chapter 8, I will return to the topic of argumentation schemes to consider how schemes and interactions between them can be formalised using established methods of argument representation.

Chapter 7

Parmenides System II

7.1 Overview

In this chapter, I discuss extensions to the Parmenides system which allows it to make use of the research that I presented into argumentation scheme interactions in Chapter 6. The aim of these extensions to Parmenides is to enhance the process of argumentation by allowing more fine-grained critique of the justifications behind the policies proposed by the government. This is achieved by allowing the creators of debates to instantiate additional arguments to support the various premises of their initial position.

I start in Section 7.3 by describing the extensions to the debate creation system which allow it to make use of additional argumentation schemes. In Section 7.4, I describe how users of Parmenides can view and critique the supporting arguments through the Parmenides debate critique website. Finally, Section 7.5 describes how the data collected from user critiques of argumentation scheme interactions is used by extensions to the analysis tools, in order to provide a fine-grained analysis of users' disagreements with the premises of the debate.

7.2 Introduction

In Chapter 6, I considered how the critical questions of one argumentation scheme can be responded to by using a different scheme. In this chapter, I develop these theories of scheme interaction into a software implementation in terms of extensions to the original Parmenides system, as described earlier in Chapter 5.

Extensions, enhancements, and additions to Parmenides have been implemented in a number of different areas of the system, as summarised below:

- The Debate Creator, which has been extended to allow the guided entry of new argumentation schemes into the system. Further extensions to the Debate Creator allow administrators to support premises of their position using arguments instantiated using these additional schemes.

- The Argumentation Scheme Catalog, a web-based repository of argumentation scheme information, with details of the formulation of the scheme, and which particular critical questions the scheme is best suited to responding to. This is informed by the investigations carried out in Chapter 6.
- The Parmenides webpages, which have been extended to allow users to view and critique supporting arguments entered by the debate administrator.
- The analysis tools, which now analyse users' critiques of supporting arguments in terms of Argumentation Frameworks, and evaluate the arguments to determine their acceptability.

I now describe each of these extensions, starting with the Debate Creator and Argumentation Scheme Catalog.

7.3 Debate Creator

In order to allow arguments within the system to be supported by other arguments instantiated using different argumentation schemes, I had to develop additional tools and modify some of the existing tools within the debate creation process of Parmenides. The main developments were as follows:

1. The addition of an interface through which new argumentation schemes and their critical questions can be entered into Parmenides, whilst preserving the semantics required to use the schemes correctly. Described further in Section 7.3.1.
2. Creation of an Argumentation Scheme Catalog, which stores information on all of the schemes used within Parmenides, including a summary of the scheme and how it can be used. Described further in Section 7.3.2.
3. Modification of the Debate Creator utility to allow premises of the initial position of a debate to be supported with evidence instantiated using other schemes. Described further in Section 7.3.3.

I now describe each of these developments in turn.

7.3.1 Entering a New Scheme Into the System

The process of entering a new argumentation scheme into the Parmenides system is guided by a PHP-based tool that I have developed. The requirement for a guided tool arises from the difficulty of instructing a computer to understand the semantics of an argumentation scheme and the associated critical questions. The system must be aware of the template-based structure of argumentation schemes, in which certain elements of the scheme are to be instantiated by the user of the scheme whilst other parts remain static, as discussed in Section 4.3. Parmenides also needs to account for the semantic formulation of the critical questions; that is, it must be able to associate the premises of the scheme that are challenged by each of the critical questions.

In light of the considerations above, the Argumentation Scheme Entry Interface was developed to allow easy and correctly formatted entry of argumentation schemes. The system is currently implemented as part of the Parmenides Profiler Administrative Interface, described in Section 5.6.2, to protect it from unauthorised access. To access it, the administrator must log into this interface and choose the "Add a new Argumentation Scheme" option from the main page.

Within this discussion, the person adding the scheme into the system is referred to as "the administrator", and the person utilising the scheme is referred to as "the user". This may differ slightly from previous discussions in which "the user" was the person submitting his or her opinion on the topic of debate.

The administrator must firstly specify the name of the argumentation scheme and the full statement of the scheme. He or she must also choose the number of "user-specified elements" in the argumentation scheme, i.e. the number of elements in the scheme that must be supplied by the user who is instantiating it. By way of example, I consider the "Argument from Expert Opinion" scheme (presented as AS2 in Appendix C), which is stated as follows:

> *Expert E is an expert in Domain D. E asserts that Fact A is known to be true. A is within D. Therefore, A may (plausibly) be taken to be true*

In this case, the user must provide the name of the expert, the domain in which the expert has expertise, and the fact asserted by the expert. This scheme therefore has three user-specified elements, which are denoted in the argumentation scheme by the phrases "Expert E", "Domain D" and "Fact A". The process of entering these details for the "Argument from Expert Opinion" scheme is shown in Figure 7.1.

After entering these basic details, the administrator then goes on to state the user-supplied elements in the argumentation scheme. After entering the user-specified elements, these are matched up with the relevant parts of the scheme statement to ensure that they have been entered correctly. This string matching allows the administrator to quickly see whether the relevant parts of the scheme have been marked-up correctly as user-specified elements. The marking-up of user specified elements of the "Argument from Expert Opinion" scheme is shown in Figure 7.2.

On the next webpage, the administrator must enter all of the critical questions associated with the scheme. Care must be taken to ensure that the questions will be understandable once the user-specified element placeholders have been replaced with

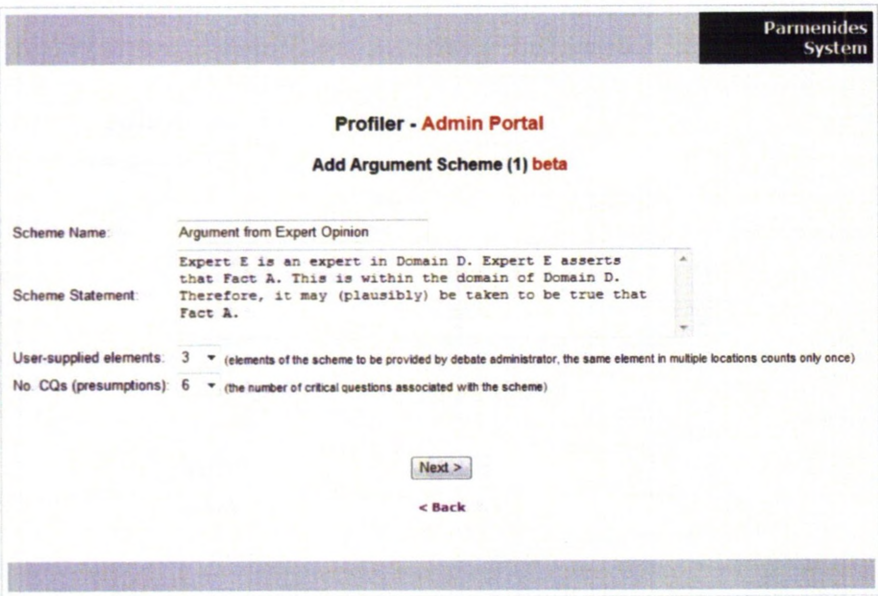


Figure 7.1: The Parmenides Argumentation Scheme Addition Interface

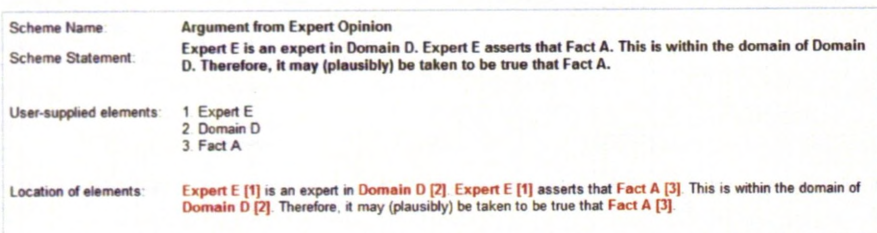


Figure 7.2: The Parmenides Argumentation Scheme Addition Interface - Marking up of user-specified elements in the scheme

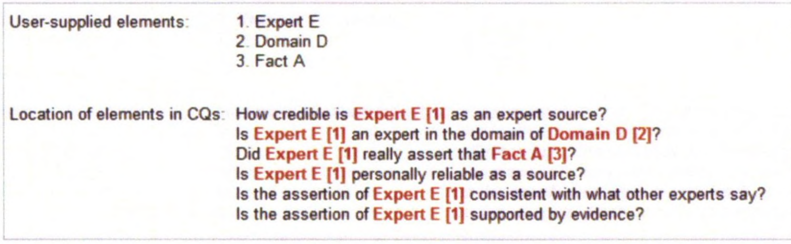


Figure 7.3: The Parmenides Argumentation Scheme Addition Interface - Marking up of user-specified elements in the critical questions

their instantiations. After the questions have been entered, the user-supplied elements in the question texts are detected, and marked for approval by the administrator (see Figure 7.3). The argumentation scheme data provided by the administrator is written to the Parmenides database, allowing the creator of a debate to use any of the schemes within the database to provide justifications for the premises of his argument.

Once the administrator has entered the scheme details, he is given the opportunity to provide further explanatory information for the scheme that he has added. This information includes a description of the scheme and typical uses of the scheme. The information provided is stored in the argumentation scheme catalogue, which I describe further in Section 7.3.2.

7.3.2 Argumentation Scheme Catalog

As briefly described above, the Argumentation Scheme Catalog is a repository of information related to the schemes implemented within the Parmenides System. I developed it to assist debate administrators in choosing the most appropriate argumentation scheme to use when instantiating arguments to support premises of his position. This is useful because although the administrator is assumed to have some knowledge of how argumentation schemes operate, the scheme catalog will contain the latest information related to the formulation of the scheme and the situations in which it is best used.

Information is added to the Argumentation Scheme Catalog during the process of adding an argumentation scheme into the Parmenides system, which I described in Section 7.3.1. The information within the Argumentation Scheme Catalog can be accessed from the Parmenides Debate Creator, through a web link which appears when the administrator has chosen to support part of their position with a responding argument (this process is described further in Section 7.3.3). Once the administrator clicks this link, the main screen of the Argumentation Scheme Catalog appears in a new Internet browser window. The main screen is shown in Figure 7.4.

The main screen lists all of the argumentation schemes entered into Parmenides using the Parmenides Argumentation Scheme Entry Interface. To get more information

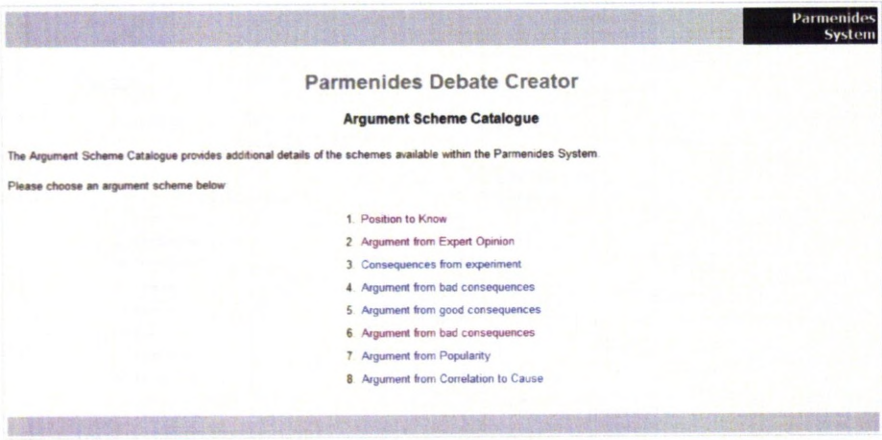


Figure 7.4: The Parmenides Argumentation Scheme Catalog - Main Screen

about a particular scheme, the administrator simply selects the scheme from the list presented. This loads a webpage on which further information on the particular scheme selected is loaded from the Parmenides database and displayed. In Figure 7.5, the Argumentation Scheme Catalog information for the Argument from Position to Know scheme is illustrated.

The information displayed on this page for each scheme within the catalogue is as follows:

1. **Scheme name** - The name of the argumentation scheme

2. **Scheme statement** - The full statement of the argumentation scheme, including the elements which will later be instantiated by the user of the scheme

3. **Scheme description** - A general description of the scheme, and the kind of argument that can be represented using the scheme. This is a summary of information available in the literature related to the particular scheme and argumentation schemes in general

4. **Typical usage** - A description of how the scheme is typically used in the context of argumentation scheme interaction, i.e. information on which premises of the practical reasoning scheme this scheme will provide an appropriate and/or persuasive response to. This information is informed by the research that I carried out into responses to the practical reasoning argumentation scheme, as described in Chapter 6.

5. **Additional comments** - Any additional comments related to the scheme or its usage are listed here. For example, if the scheme is deemed particularly unper-

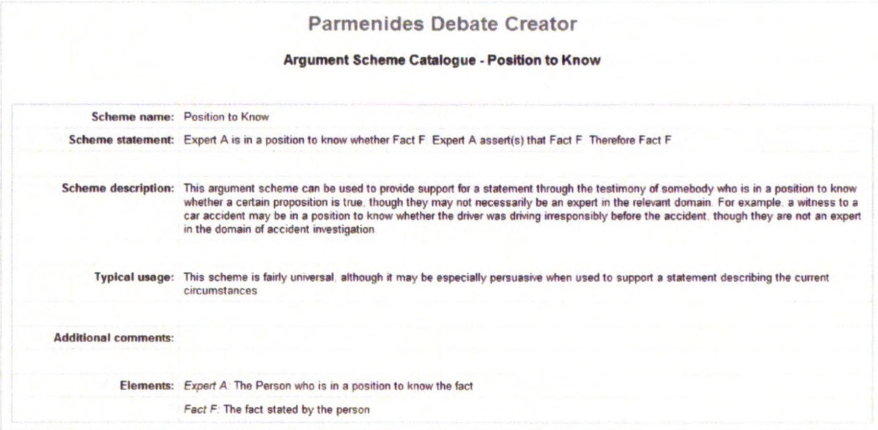


Figure 7.5: The Parmenides Argumentation Scheme Catalog - Further Scheme Information

suasive in supporting particular elements of the practical reasoning scheme, this may be discussed here.

6. **Elements** - A listing of all of the elements of the scheme which are later instantiated by the proponent of the argument. The name of the element is given, along with a description of what information should be provided here to instantiate the scheme.

I now describe how the schemes present within the Argumentation Scheme Catalog can be used during the debate creation process.

7.3.3 Supporting an argument using another Scheme

Having already described the addition of argumentation schemes into Parmenides in Section 7.3.1, and the catalog through which details of schemes can be viewed in Section 7.3.2, I now turn to describing how the proponent of a debate can make use of these additional schemes in supporting his position.

Firstly, the administrator must create the debate in the normal way using the Debate Creator, as described in Section 5.3.2. However, when the administrator creates the initial position of the debate, she is now given the option to add supporting evidence to each of the premises.

For example, when the administrator specifies the circumstances of her position, she may wish to provide an additional argument that supports the truth of these circumstances. This is effectively posed to the user of Parmenides as a response to the critical question "Are the circumstances as described?", since if the user disagrees with

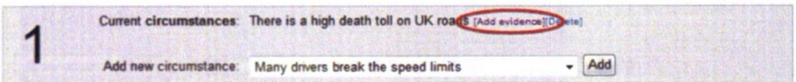


Figure 7.6: The Parmenides Debate Creator - Adding Evidence to a Premise

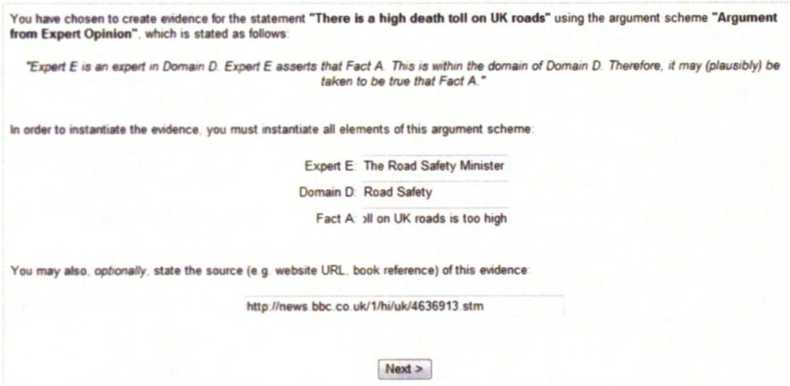


Figure 7.7: The Parmenides Debate Creator - Instantiating Evidence

this critical question then he is given the opportunity to critique the supporting argument.

To add a supporting argument to a particular premise, the administrator clicks the "Add evidence" link next to the premise that she has added to the initial position of the debate. For the remainder of this section, and for the next section in which I describe analysis of argumentation scheme interaction data, I will use as an example the addition of supporting evidence to the circumstance statement "There is a high death toll on UK roads", which is taken from the Speed Camera Debate introduced earlier. Figure 7.6 illustrates the position of the "Add evidence" link in relation to this circumstance statement.

After clicking this link, the administrator is taken to a new webpage on which she is asked to choose the argumentation scheme that she would like to use to instantiate her evidence. If the administrator is unsure which scheme she wishes to use, then she can access the Argumentation Scheme catalog by clicking the link present on this page. Once the administrator has chosen the appropriate scheme, she is taken to the next webpage on which she is given the opportunity to instantiate the various elements of the scheme with the information relevant to her argument. The full statement of the scheme is also shown on this page in order to assist the administrator in entering the details correctly. Finally, at the bottom of this webpage, the administrator can state the source of the evidence if desired, which will later be displayed to the user when he critiques the argument. This webpage is shown in Figure 7.7.

The administrator is then taken to another webpage on which she is given the op-

Figure 7.8: The Parmenides Debate Creator - Viewing Instantiated Evidence

portunity to review, amend and save the instantiated argumentation scheme, as shown in Figure 7.8. Once the argument instantiation has been accepted, the argument is saved and associated with the relevant premise of the initial position.

This concludes the process of adding a supporting argument to part of the initial position put forward by the proponent of the initial position. If the administrator wishes to edit or remove the supporting argument, this can be achieved by clicking the "View/Edit evidence" link that appears next to the relevant premise, which takes the administrator to the webpage shown in Figure 7.8.

Having described how supporting arguments can be associated with premises of the initial position in the process of creating a new debate, I will now turn to describing how the supporting arguments are displayed to the user and ultimately critiqued on the Parmenides website.

7.4 Critiquing a Supporting Argument

In order to facilitate the display and critique of supporting arguments within Parmenides, I had to implement extensions to the standardised Parmenides debate critique webpages, originally described in Chapter 5. In this section, I will demonstrate how the supporting argument added to The Speed Camera Debate in Section 7.3.3 is viewed and critiqued by participants in the debate.

The first indication that supporting arguments are available within the debate is on the page on which the initial position of the debate is presented to the user. Any parts of the initial position which have supporting arguments associated with them appear as underlined hyperlinks which, when clicked, pop up a new browser window which displays the supporting argument to the user. This is shown in Figure 7.9.

The user continues to critique the initial position of the debate in the normal manner, by answering the critical questions associated with the argumentation scheme. Again, where the user is responding to a statement which is supported by another argument, such statements are underlined so that users can click on them to view the underlying argument in a pop up window. In the updated version of the Parmenides website, the user is taken to the next webpage as normal if he answers "Yes" to the critical question or answers "No" to a critical question which is not supported by a further argument.

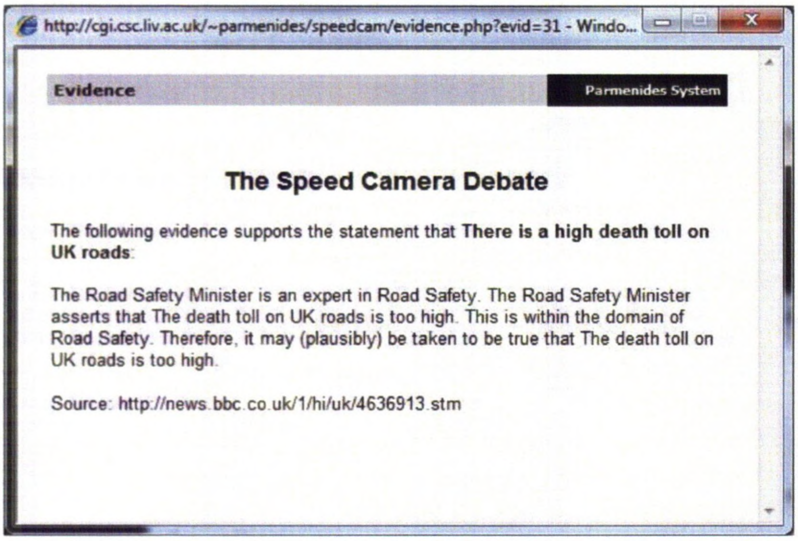


Figure 7.9: The Parmenides Website - Viewing Evidence

However, if the user responds "No" to a critical question which *is* supported by another argument, then he is taken to a different webpage on which the supporting argument is presented. I consider again the running example of The Speed Camera Debate, which has a supporting argument attached to the circumstance statement "There is a high death toll on UK roads". Thus, if the user states his disagreement with this statement during the critique of the circumstances of the debate, he is taken to the webpage shown in Figure 7.10. On this page the user is shown the argument which supports this statement, as instantiated by the debate administrator using the "Argument from Expert Opinion" scheme. He is then given the chance to critique the argument by considering all of the critical questions related to the scheme.

The general list of critical questions associated with the scheme are posed to the user first. These challenge the various premises of the supporting argument, but they do not consider the link between the supporting argument and the premise being supported. These critical questions simply consider the supporting argument as a standalone argument. The final critical question added to all supporting arguments within the Parmenides system challenges the connection between the conclusion of the supporting argument and the supported premise in the initial position. This is an important critical question, as even if the user believes that the supporting argument is valid, he may not necessarily believe that it licences the supported premise within the initial position.

Once the user has answered the critical questions, he is taken back into the Parmenides system and proceeds to critique the rest of the argument in the usual manner. When the user reaches the final results page, as shown in Figure 5.7, he can view the

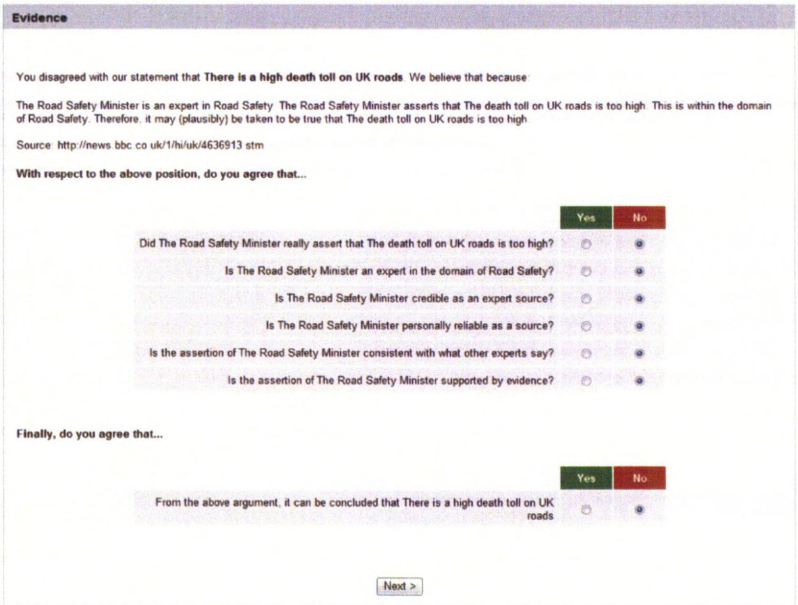


Figure 7.10: The Parmenides Website - Critique of Evidence

critique of any evidence that he has responded to by clicking the "View reasoning" link next to the relevant premise(s). This brings up a new browser window on which the results of his evidence critique are shown.

The user has now not only stated his disagreement with the statement that there is a high death toll on UK roads, but also stated agreement or disagreement with an argument that supports this statement. This allows the proponent to put arguments forward in a way that more closely mimics real life argumentation - if the user disagrees with the position proposed then the proponent is given the opportunity to propose a supporting argument and to see exactly which part of this supporting argument the user agrees or disagrees with. Analysis of the resulting data could provide interesting information about how and why users disagree with particular statements and the arguments given to support these statements. It is the analysis aspect of the Parmenides extensions that I describe next.

7.5 Analysis Tools

In addition to the extensions and modifications to the Parmenides Debate Creator and the Parmenides website, I have also extended the Parmenides analysis tools in order to allow analysis of the extra data obtained as a result of the argumentation scheme interactions.

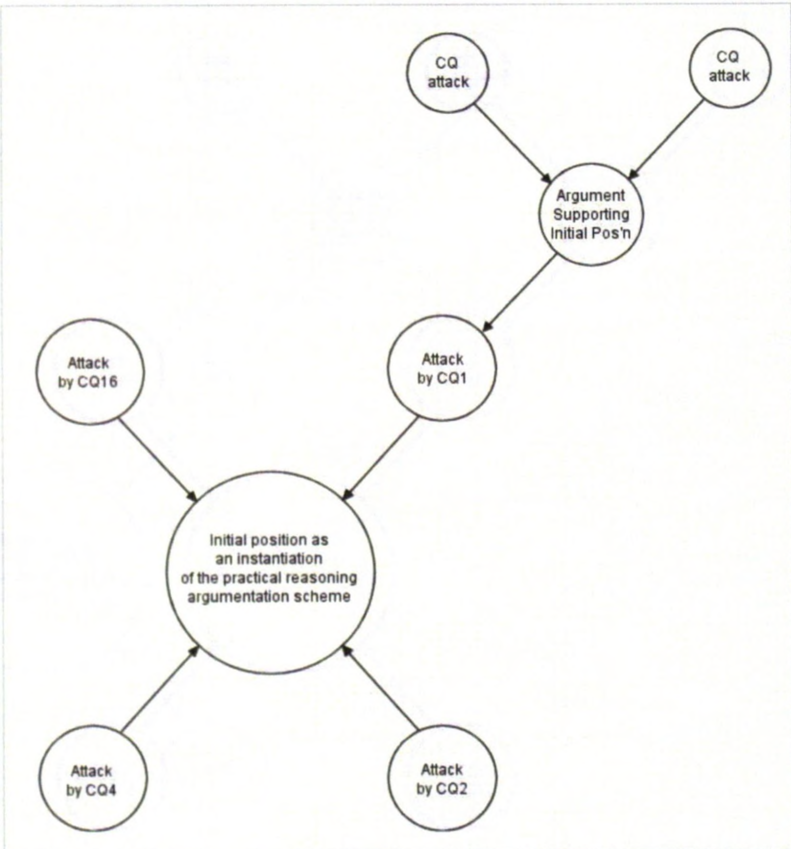


Figure 7.11: Schema

The extensions within the analysis toolset have been implemented within the "Critique Statistics Analysis Tool", in the form of additions to the Argumentation Frameworks used to evaluate arguments. Responses to arguments that support a particular premise within a debate are represented as additional nodes within the branch of the AF which represents the relevant part of the argument. An example of the schema used to represent the new data is given in Figure 7.11.

Within the Argumentation Framework, supporting arguments are represented as attacks on critical questions that challenge the relevant premises. The supporting arguments themselves are attacked by the critical questions associated with the argumentation scheme with which they are instantiated. One can imagine how this chain of support and attack could continue indefinitely, however an indefinite chain is unlikely to be desirable as it is unlikely to provide further useful information and would remove focus from the original topic of debate. For this reason, Parmenides only permits one level of support.

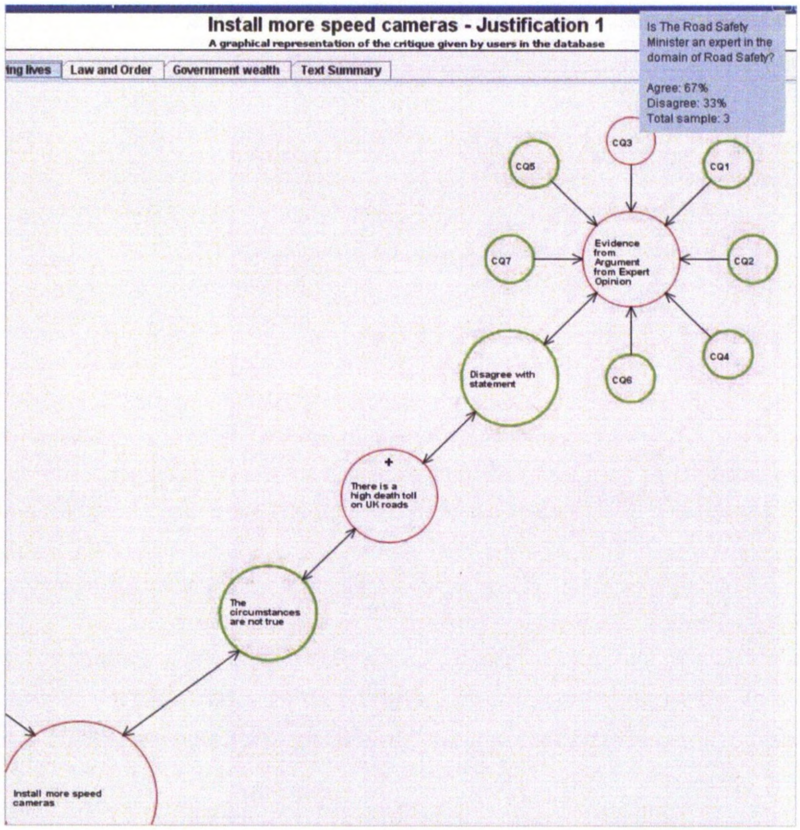


Figure 7.12: Parmenides Analysis Tools - Analysis of Supporting Arguments

I now consider again the running example used throughout the chapter of a supporting argument for The Speed Camera Debate. This particular supporting argument is associated with the circumstance statement of one of the justifications within the debate, and hence appears as an extension to the branch of the AF that is related to the circumstances. This is shown in Figure 7.12. The administrator can choose to collapse this extension to the branch if she desires, in order to view only nodes relating directly to the critique of the initial position. This is achieved by clicking the "+" icon near the top of the node representing the supported premise. This is visible in the node representing the statement "There is a high death toll on UK roads" in Figure 7.12.

When the supporting argument branch is expanded, an extra node is added between the node representing the supporting argument and the premise which it supports - this is to preserve the semantics of the Argumentation Framework, which supports only attack relationships and not relationships representing support. The semantics of Argumentation Frameworks were discussed in Chapter 2.

The node within the framework that represents the supporting argument contains the name of the argumentation scheme used to instantiate the argument (in the case of our example, "Argument from Expert Opinion"). By hovering the mouse over this node, the full instantiation of the scheme is shown. Surrounding the supporting argument are the critical questions which challenge its premises. Again, the nodes are only marked with CQ numbers in order to aid visual clarity of the framework. Hovering the mouse over a particular critical question node allows the user to view the respective critical question text. In addition, the percentage of users who agreed and disagreed with the attack is shown, together with the total number of responses. Due to the phrasing of the critical questions, the node colouring is slightly different to some of the other nodes in the framework: Where most users agree with the critical question (e.g. "Is the Road Safety Minister an expert in the domain of road safety?"), then the node is coloured red, as the attack of the critical question does not succeed. Conversely, where most users disagree with the critical question then the node is coloured green. The debate administrator must ensure that critical questions are entered into the system correctly (so that answering "No" to the CQ implies an attack on the argument generated by an instantiation of the argumentation scheme) in order to ensure correct operation of the analysis tool.

In Figure 7.12, the supporting argument has a red outline as it is defeated by one or more critical questions. If none of the critical questions is successful in attacking the argument (i.e. they all have red outlines), then the supporting argument itself will have a green outline. However, in order to provide the maximum level of analysis detail to the administrator, the acceptability of the supporting argument does not have an effect on the acceptability of the premise being supported. Thus, even if the supporting argument is accepted, the supported premise will still be indicated in red if users did not agree with the premise itself. This scenario is illustrated in Figure 7.13. This is to ensure that the administrator is still able to quickly see whether most users did or did not agree with the premise, regardless of their response to its supporting argument.

As a future development of the system, it may be desirable to implement an option to change the semantics used for evaluation of supporting arguments and the respective premises. One such option could be to change the colour of the supported premise to green, if the supporting argument has majority agreement. The semantics that are currently implemented are intended to be a trade-off that does not result in the loss of any data, despite not fully conforming to the acceptability semantics of Argumentation Frameworks that were set out by Dung in [45].

In addition to extensions to the graphical representation of critique statistics data, I have also extended the textual analysis to show information related to supporting arguments. Now, if a particular premise is supported by evidence it is suffixed with a "+" symbol which, when clicked, displays a pop-up window showing details of the supporting argument for the premise. I chose to show the evidence in a pop-up window rather than within the main textual summary in order to avoid over-populating the display.

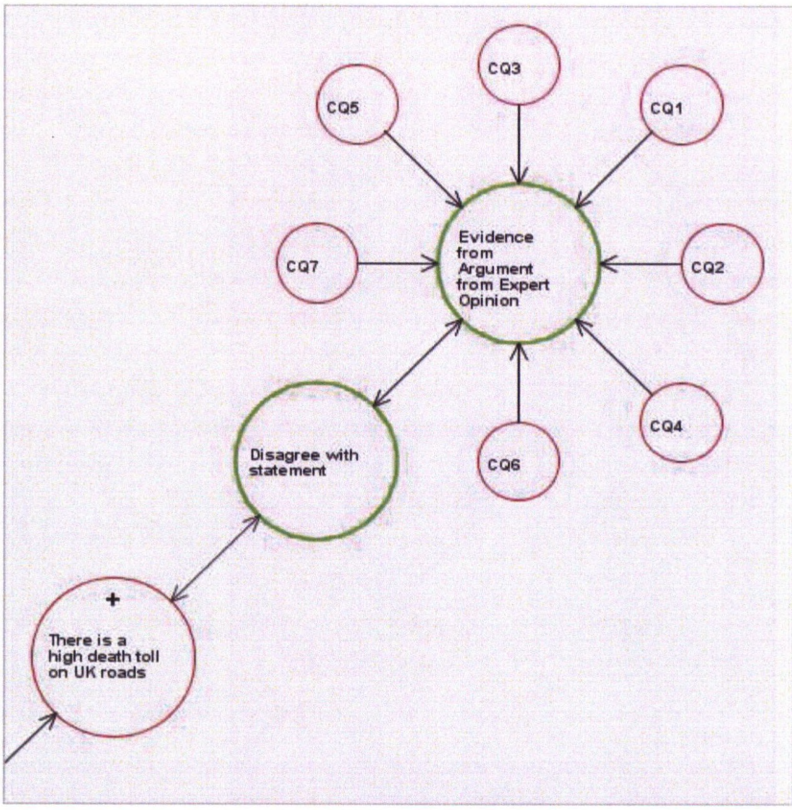


Figure 7.13: Parmenides Analysis Tools - Agreement with Supporting Argument

Additionally, debate administrators may not always be interested in the results of the supporting argument critiques, and hence they can choose not to view this data at all. Within the pop-up window, the full statement of the supporting argument is displayed, along with the critical questions and the percentage agreement with each question.

7.6 Summary

In this chapter, I have described extensions to the Parmenides system which allow premises of the initial position to be supported by arguments instantiated using a range of argumentation schemes. Firstly, I discussed how additional schemes can be added in to Parmenides using a computer-guided interface which ensures that schemes are formulated correctly. I also described the Argumentation Scheme Catalog, which provides a repository of information related to argumentation schemes and how they can be used, informed by the research described in Chapter 6.

I then went on to discuss how supporting arguments can be instantiated using extensions to the Debate Creator system, which guide the debate administrator through the process of creating additional arguments. I described how supporting arguments are displayed to the user and critiqued through the Parmenides website, and how the resulting data is analysed using extensions to the Parmenides Analysis Tools.

In the next chapter I will consider how argumentation schemes and the interaction between schemes can be formalised, in order to aid development of automated software systems which can make use of them.

Chapter 8

Decision Making in Agent-based Systems

8.1 Overview

So far in this thesis, I have discussed how the Parmenides system utilises argumentation schemes in order to provide a structured method of collecting and analysing arguments from human users. In this chapter, I discuss how arguments based on practical reasoning problems can be automatically reasoned with using computational tools, and examine how this could be of use both in systems such as Parmenides as well as argumentation tools in other domains. I consider an existing formalisation of the practical reasoning argumentation scheme and demonstrate how a running example used throughout this thesis, The Speed Camera Debate, can be represented and reasoned with using this formalism.

8.2 Motivation

In all of the discussions so far in this thesis, the consideration of argumentation schemes has been in terms of their representation in natural language. Indeed, this is one of the key reasons for the use of argumentation schemes in the Parmenides system: their natural formulation makes them easy for a general audience to understand. However, the natural language representation of argumentation schemes causes issues when we turn to consider how computational systems can perform automated reasoning on the schemes. In such systems the arguments are put forward by, and possibly attacked/defended by, one or more operating computational agents. The acceptability of each of the positions put forward in the situation may also be calculated computationally by software tools. The development of such automated methods of reasoning could bring benefits to tools such as Parmenides, for example by identifying points of weakness in an argument before it is made available to the public. Developing automated methods for reasoning with arguments is also a benefit in it's own right, as it could be used in agent-based systems to allow agents to effectively reason over arguments.

In order to be able to perform rigorous reasoning about different types of argument, we need a well defined formalism in which we can represent the argumentation schemes on which they are based. We also need some way of representing the effects of carrying out actions proposed by arguments.

A formalism has been developed for practical reasoning, using the scheme and critical questions underlying Parmenides, in terms of an Action-based Alternating Transition System (AATS) [6]. AATSs were originally designed to provide a semantic structure for Alternating-time Temporal Logic [2]. The AATS provides a framework for taking into consideration all of the possible actions that could be performed in an initial state (possibly by multiple operating agents), and the states that would be reached by performance of each action. In [6], an extension to the AATS was proposed which enables the promotion and demotion of social values to be attached to each state transition, thus enabling formalisation of the practical reasoning argumentation scheme. The fullest account of this formalism is [7].

The aim of the work in this chapter is to discuss this existing work in the formal representation of argumentation schemes, and illustrate the use of the formal structure and its relation to the work of this thesis by instantiating it with an example debate. I conclude the chapter with a discussion of existing and future uses of the AATS, both in relation to Parmenides and in other domains, and consider how argument interaction could be formalised within an AATS.

8.3 Formalising the Practical Reasoning Scheme

In this section I will introduce the Action-based Alternating Transition System (AATS), describe the formal notation used within the system, and then discuss how Atkinson's practical reasoning argumentation scheme was represented using the AATS in [7]. I will then instantiate an example debate using the AATS structure, to illustrate the usefulness of the representation.

An AATS provides a framework for representing the transitions between states, as well as the propositions that are true in each of these states. Crucially it also provides us with the concept of a "joint action", allowing us to represent the set of possible actors within the scope of the argument, the actions that these actors perform in order for each state transition to occur, and the effect that the different actions have on each other. In [6] and [7], an extension to the AATS was proposed which enables value promotion/demotion to be attached to each state transition. This was used to provide a formal characterisation of the conditions under which Atkinson's practical reasoning argumentation scheme could be instantiated, and also the conditions under which the critical questions can be posed.

8.3.1 Formulating the Action-based Alternating Transition System

The AATS was originally defined in [155], which is cited by Atkinson and Bench-Capon in [7], and expanded in the same paper in order to accommodate the concept of social values, an essential component in representing the practical reasoning argumentation scheme in terms of an AATS.

The AATS consists of a finite set of states, Q, of which $q_0 \in Q$ is the *initial state* of the system. The system contains a set Ag of *agents*, where each agent $i \in Ag$ is associated with a set Ac_i of possible actions. It is assumed that the sets of actions are mutually disjoint, i.e. actions are unique to agents. A joint action j_C for a coalition C (a coalition is a set of agents) is a tuple $\langle \alpha_1, ..., \alpha_k \rangle$, where for each α_j (j $\leq$ k) there is some $i \in C$ such that $\alpha_j \in Ac_i$. Moreover, there are no two different actions α_j and $\alpha_{j'}$ in j_C that belong to the same Ac_i. The set of all joint actions for coalition C is denoted by J_C, so $J_C = \prod_{i \in C} Ac_i$. Given an element j of J_C and an agent $i \in C$, i's action in j is denoted by j_i.

Thus, an AATS is defined in [155] as an (n+7)-tuple S = $\langle$Q, q_0, Ag, Ac_1,....Ac_n, ρ, τ, Φ, $\pi\rangle$, where:

- Q is a finite, non-empty set of *states*;
- $q_0 \in Q$ is the *initial state*;
- $Ag = \{1,...,n\}$ is a finite, non-empty set of *agents*;
- Ac_i is a finite, non-empty set of actions, for each $i \in Ag$ where $Ac_i \cap Ac_j = \emptyset$ for all $i \neq j \in Ag$;
- $\rho : Ac_{Ag} \rightarrow 2^Q$ is an *action pre-condition function*, which for each action $\alpha \in Ac_{Ag}$ defines the set of states $\rho(\alpha)$ from which α may be executed;
- $\tau : Q \times J_{Ag} \rightarrow Q$ is a partial *system transition function*, which defines the state $\tau(q, j)$ that would result by the performance of j from state q – note that, as this function is partial, not all joint actions are possible in all states (cf. the pre-condition function above);
- Φ is a finite, non-empty set of *atomic propositions*; and
- $\pi : Q \rightarrow 2^\Phi$ is an interpretation function, which gives the set of primitive propositions satisfied in each state: if $p \in \pi(q)$, then this means that the propositional variable p is satisfied (equivalently, true) in state q.

As mentioned earlier, in order to represent the practical reasoning argumentation scheme, Atkinson and Bench-Capon extended the AATS representation in [7] to enable the representation of social values. A set A_v of values are provided for each agent, which are a subset of a set V of values. Each value is either promoted, demoted, or neutral by each transition between two states of Q. The promotion or demotion of a value is determined by comparing the state reached with the previous state. Finally, values are not unique to agents, meaning that two or more agents may or may not have values in common. The formal definition of the extended elements of the AATS are as follows:

- Av_i is a finite, non-empty set of values $Av_i \subseteq V$, for each $i \in Ag$.

- $\delta : Q \times Q \times Av_{Ag} \rightarrow \{+, -, =\}$ is a *valuation function* which defines the status (promoted (+), demoted (–) or neutral (=)) of a value $v_u \in Av_{Ag}$ ascribed by the agent to the transition between two states: $\delta(q_x, q_y, v_u)$ labels the transition between q_x and q_y with one of $\{+, -, =\}$ with respect to the value $v_u \in Av_{Ag}$.

The extended AATS is therefore defined as a (2n+8) tuple S = $\langle Q, q_0, Ag, Ac_1,....Ac_n, Av_1,....Av_n, \rho, \tau, \Phi, \pi\delta \rangle$. I now turn to consider how the argumentation scheme for practical reasoning, and its associated critical questions, can be represented using the AATS formalisms defined above.

8.3.2 Formalising the Practical Reasoning scheme in an AATS

The eventual aim of the work presented in this chapter is to represent the Speed Camera Debate, as presented in Chapter 5, formally in terms of an AATS. The first step in achieving this is to define the practical reasoning argumentation scheme used to instantiate this debate, in terms of the AATS described in Section 8.3.1.

In [7], Atkinson and Bench-Capon describe three "stages" of practical reasoning. These stages allow us to define not only exactly how a practical reasoning problem is constructed using an AATS, but also exactly which parts of this construction are challenged by each of the critical questions. Thus, it also provides a classification of the critical questions according to the phase of practical reasoning in which they occur. These stages are as follows:

1. **Problem formulation** - Deciding on the propositions and values relevant to the particular situation, and constructing the AATS.

2. **Epistemic reasoning** - Determining the initial state of the AATS formed in the first stage.

3. **Choice of action** - Developing the appropriate arguments and counter arguments, in terms of the argumentation scheme and critical questions, and deter-

mining the status of arguments with respect to other arguments and the value orderings.

The stages are carried out sequentially, but may iterate if critical questioning leads to a reformulation of the problem.

8.3.2.1 Formalising the Premises

I now state the formalisation of the practical reasoning argumentation scheme in terms of an AATS, as described in [7]. By way of a reminder, the scheme is stated as follows:

> In the circumstances R, we should perform action A, to achieve consequences S, which will realise some goal G, which will promote some value V.

The formulation of the above scheme in an AATS is as follows. The notation used in the following description was described in Section 8.3.1:

- Circumstances (initial state) q_0 : $q_0 = q_x \in Q$
- Action j_n: Agent $i \in Ag$ should participate in joint action $j_n \in J_{Ag}$ where $j_n^i = \alpha_i$
- Consequences $q_y : \tau(q_x, j_n)$
- Goal p_a or $\neg p_a : p_a \in \pi(q_y)$ and $p_a \notin \pi(q_y)$ and $p_a \in \pi(q_x)$
- Social value $v_u : v_u \in Av_i, \delta(q_(x), q_y, v_u)$ is +.

Having formalised the argumentation scheme itself, I now turn to consider the representation of the critical questions associated with the scheme.

8.3.2.2 Formalising the Critical Questions

In [7], a discussion of exactly which part of the AATS structure each critical question attacks is provided. It is noted that each particular critical question challenges one of the three phases of practical reasoning that I described in Section 8.3.2. Eight of the critical questions are identified as falling under the *problem formulation* stage of the practical reasoning process, with two falling under *epistemic reasoning*, and a further seven under the *choice of action* stage. The precise account of which critical question falls into which particular category is given later in this section.

One may notice that this totals seventeen critical questions, whereas the original version of the scheme contains exactly sixteen critical questions. The representation of the scheme in the AATS requires the addition of CQ17, which is stated in [6] as: *"Is the other agent guaranteed to execute its part of the desired joint action?"*. This critical question is required because the AATS introduces the concept of a "joint action", which considers the participation of two or more agents in carrying out an action. This is in contrast to the original formulation of the practical reasoning scheme, which only considered an action performed by a single agent. Hence, within an AATS, the co-operation of other agents is required in order to move between states. If one or more of the participating agents does not co-operate, then the system could end up in a different state to the one intended. As agents are autonomous and so the co-operation of the other agent(s) can not be guaranteed, it must be possible to pose a critical question attack against the assumption that all involved agents will co-operate.

The sixteen critical questions associated with the scheme, coupled with the additional critical question which challenges co-operation of other agents in the joint action, are as follows:

CQ1: Are the believed circumstances true?

CQ2: Assuming the circumstances, does the action have the stated consequences?

CQ3: Assuming the circumstances and that the action has the stated consequences, will the action bring about the desired goal?

CQ4: Does the goal realise the value stated?

CQ5: Are there alternative ways of realising the same consequences?

CQ6: Are there alternative ways of realising the same goal?

CQ7: Are there alternative ways of promoting the same value?

CQ8: Does doing the action have a side effect which demotes the value?

CQ9: Does doing the action have a side effect which demotes some other value?

CQ10: Does doing the action promote some other value?

CQ11: Does doing the action preclude some other action which would promote some other value?

CQ12: Are the circumstances as described possible?

CQ13: Is the action possible?

CQ14: Are the consequences as described possible?

CQ15: Can the desired goal be realised?

CQ16: Is the value indeed a legitimate value?

CQ17: Is the other agent guaranteed to execute its part of the desired joint action?

I now state the formalisation of these critical questions in the AATS, as defined by Atkinson and Bench-Capon in [7]. I classify the critical questions according to the particular stage of practical reasoning that they pose an attack against.

Eight of the critical questions associated with the argumentation scheme fall under the "Problem Formulation" stage of the practical reasoning process.

CQ2 accepts that the pre-conditions for carrying out the action hold (i.e. the circumstances), but disputes the state reached through performing the action. CQ3 accepts the state reached through performing the action, in addition to the pre-conditions of the action, but disputes the truth of a proposition (the goal) within the resulting state. CQ4 allows agents to disagree as to what promotes a particular value. CQ12 disagrees as to relevant propositions; CQ13 disputes the actions available; CQ14 and CQ15 also relate to the existence of particular states; and CQ16 raises a dispute about the legitimacy of a value.

The formalisation of these eight critical questions in terms of the AATS representation is as follows:

CQ2: $\tau(q_x, j_n)$ is not q_y.

CQ3: $p_a \notin \pi(q_y)$.

CQ4: $\delta(q_x, q_y, v_u)$ is not $+$.

CQ12: $q_x \notin Q$.

CQ13: $j_n \notin J_{Ag}$.

CQ14: $\tau(q_x, j_n) \notin Q$.

CQ15: $p_a \notin \pi(q)$ for any $q \in Q$.

CQ16: $v_u \notin V$.

Two critical questions fall into the "epistemic reasoning" stage of practical reasoning - that is, their resolution to determines the initial state of the structure.

CQ1 questions whether the initial state has been correctly identified, that is whether some of the beliefs supporting the argument are not true. The second and final critical question in this category is CQ17, the additional critical question developed to challenge the co-operation of other agents in the joint action. CQ17 falls into the "epistemic reasoning" stage because the uncertainty over the resulting state is due to the lack of knowledge of other agents' choices.

The formalisation using AATS constructs is as follows:

CQ1: $q_0 \neq q_x$ and $q_0 \notin \rho(\alpha_i)$.

CQ17: $j_n{}^i = j_m{}^i$, $j_n \neq j_m$ and $\tau(q_x, j_n) \neq \tau(q_x, j_m)$.

A further eight critical questions are all pertinent to the final stage of the practical reasoning process, "Choice of action".

CQ5, CQ6, and CQ7 all consider the effect of performing an alternative action upon the consequences, goal, and value, respectively. CQ8 and CQ9 consider negative side effects of carrying out the action, that will demote the value promoted by the argument or some other value. Meanwhile, CQ10 considers alternative positive effects of the action - i.e. unstated values that are promoted by the action. This critical question does not seem to challenge the *performance* of the action, as it identifies positive side effects of carrying out this action. Rather, it questions the *justification* presented for carrying out the action, which can be a crucial issue when considering the acceptability of such a justification, for example if someone is attempting to mask self-interest. Finally, CQ11 identifies a mutual exclusivity between performing the proposed action, and another action which promotes some desirable value.

The AATS formalisation of the final eight critical questions is thus as follows:

CQ5: Agent $i \in Ag$ can participate in joint action $j_m \in J_{Ag}$, where $j_n \neq j_m$, such that $\tau(q_x, j_m)$ is q_y.

CQ6: Agent $i \in Ag$ can participate in joint action $j_m \in J_{Ag}$, where $j_n \neq j_m$, such that $\tau(q_x, j_m)$ is q_y, such that $p_a \in \pi(q_y)$ and $p_a \notin \pi(q_x)$ or $p_a \notin \pi(q_y)$ and $p_a \in \pi(q_x)$.

CQ7: Agent $i \in Ag$ can participate in joint action $j_m \in J_{Ag}$, where $j_n \neq j_m$, such that $\tau(q_x, j_m)$ is q_z, such that $\delta(q_x, q_z, v_u)$ is $+$.

CQ8: In the initial state $q_x \in Q$, if agent $i \in Ag$ participates in joint action $j_n \in J_{Ag}$, then $\tau(q_x, j_n)$ is q_y, such that $p_b \in \pi(q_y)$, where $p_a \neq p_b$, such that $\delta(q_x, q_y, v_u)$ is $-$.

CQ9: In the initial state $q_x \in Q$, if agent $i \in Ag$ participates in joint action $j_n \in J_{Ag}$, then $\tau(q_x, j_n)$ is q_y, such that $\delta(q_x, q_y, v_w)$ is $-$, where $v_u \neq v_w$.

CQ10: In the initial state $q_x \in Q$, if agent $i \in Ag$ participates in joint action $j_n \in J_{Ag}$, then $\tau(q_x, j_n)$ is q_y, such that $\delta(q_x, q_y, v_w)$ is $+$, where $v_u \neq v_w$.

CQ11: In the initial state $q_x \in Q$, if agent $i \in Ag$ participates in joint action $j_n \in J_{Ag}$, then $\tau(q_x, j_n)$ is q_y and $\delta(q_x, q_y, v_u)$ is +. There is some other joint action $j_m \in J_{Ag}$, where $j_n \neq j_m$, such that $\tau(q_x, j_m)$ is q_z, such that $\delta(q_x, q_z, v_w)$ is +, where $v_u \neq v_w$.

I now illustrate the usefulness and applicability of the AATS structure by instantiating it with an example debate.

8.3.3 Representing The Speed Camera Debate

In this section, I will apply the AATS-based formalisation of the practical reasoning argumentation scheme discussed in the previous section to an example practical reasoning problem. The particular example that I have chosen to use is one that was presented in the discussions of the Parmenides system in Chapter 5 and Chapter 7, based around the installation of speed cameras on UK roads. The argument put forward by the debate concludes with the suggested action of installing more speed cameras on UK roads[1]:

> In the current circumstances *there is a high death toll on UK roads, drivers break the speed limits, the government make money from speeding fines*, we should *install more speed cameras*, which will result in *a reduction in the death toll, a reduction in speeding drivers, increased government revenue*, which will promote *saving lives, law and order, and government wealth.*

In order to represent the example in terms of the AATS formalism, I firstly define the propositions relevant to each of the states. By examination of the textual version of the argument given above, we can define the states as being made up of **Speed Limits**, which are either broken or obeyed, **Roads Death Toll**, which could be low or high (with "high" being the presumed current state), and **Government Wealth**, which is either low, medium, or high ("medium" being presumed as the current state). A full representation of the states within the AATS is presented in Table 8.1, where I use the following abbreviations: H = High, M = Medium, L = Low, O = Observed, B = Broken.

After considering all of the available states, we can go on to consider the possible joint actions that enable movement between these states. Again, I identify the agents from the instantiation of the argument given earlier, and define the actions that each

[1]The debate was originally presented as three separate instantiations of the practical reasoning argumentation scheme, one for each value promoted. Here, to aid visual clarity, the elements of the three instantiations are conflated into one instantiation of the scheme. For the purposes of this discussion, the conflation of the three instantiations into one does not result in any loss of detail.

	Death Toll	Wealth	Speed Limits
q0	H	M	B
q1	H	M	O
q2	H	L	B
q3	H	L	O
q4	H	H	B
q5	H	H	O
q6	L	M	B
q7	L	M	O
q8	L	L	B
q9	L	L	O
q10	L	H	B
q11	L	H	O

Table 8.1: Possible states within the Speed Camera AATS

agent can carry out. The agents are **The Government**, who can do nothing, educate drivers, or install more speed cameras; **Drivers**, who can either do nothing, or reduce their speed; and **Police**, who can do nothing or prosecute drivers. To represent the element of indeterminacy in the various actions, I introduce a further agent, **Nature**, which I employ to represent whether the death toll is reduced or not. The resulting joint actions are as per Table 8.2, where I use the following abbreviations: N = Do nothing, C = Install speed cameras, E = Educate drivers, RS = Reduce speed, RA = Reduce accidents.

This potentially gives twenty four joint actions, but some of them can be discounted. For example, one joint action (j1) represents an action in which the only actor to do anything is Nature, which reduces accidents without any change in behaviour by the other agents. Since, in this context, we are considering actions that should be carried out to reduce the death toll on our roads, we need not consider a scenario in which the death toll falls without any action being carried out: it is a basic assumption that some action is needed to achieve a reduced death toll.

Some joint actions will not take place because the performance of a particular action by one agent relies on the co-operative performance of another action by another agent. For this reason, I do not consider the following joint actions (denoted by a * in Table 8.2):

- **j3** is not considered because it is not likely that if the police prosecute speeding drivers, but drivers do not reduce speed, that this will reduce accidents.

- I do not consider **j4** or **j5**, in which drivers reduce their speed without any external influence.

	Gov't	Drivers	Police	Nature
j0	N	N	N	N
j1*	N	N	N	RA
j2	N	N	P	N
j3*	N	N	P	RA
j4*	N	RS	N	N
j5*	N	RS	N	RA
j6	N	RS	P	N
j7	N	RS	P	RA
j8	C	N	N	N
j9*	C	N	N	RA
j10	C	N	P	N
j11*	C	N	P	RA
j12	C	RS	N	N
j13	C	RS	N	RA
j14	C	RS	P	N
j15	C	RS	P	RA
j16	E	N	N	N
j17	E	N	N	RA
j18	E	N	P	N
j19	E	N	P	RA
j20	E	RS	N	N
j21	E	RS	N	RA
j22	E	RS	P	N
j23	E	RS	P	RA

Table 8.2: Joint actions within the Speed Camera AATS

- **j9** is not considered as it is illogical that accidents would be reduced after the installation of speed cameras, if drivers do not react to the presence of cameras (by reducing their speed).
- Similarly, **j11** represents a case in which the police prosecute speeding drivers, and accidents are reduced despite drivers not reducing their speed. The incoherency of this argument excludes it from consideration here.

In the process of creating the full list of possible states and the actions required to move between these states, the debate creator is forced to consider his debate in more detail. He must consider a selection of other actions that could be carried out in addition to the one that he proposes, as well as the possible outcomes (resulting states) of these actions. So in addition to being a useful model for formally representing arguments, the AATS presents itself as a mechanism which can be used to ensure that debates are carefully considered by their proponent.

The final stage of formalising the argument in terms of an AATS is to design the state transition matrix. This tells us the resulting state that occurs if a particular joint action is performed in a particular state. It also indicates the values that are promoted (indicated with a +) or demoted (indicated with a -) as a result of performing the action. The full transition matrix is shown in Table 8.3 and Table 8.4. The social values promoted by the transition to each state are abbreviated as follows: S = Saving Lives, W = Government Wealth, L = Law and Order.

	q0	q1	q2	q3	q4	q5
j0	q0[]	q1[]	q2[]	q3[]	q4[]	q5[]
j2	q4[+W]	q5[+W]	q0[+W]	q3[]	q4[]	q5[]
j6	q1[+L]	q1[]	q3[+L]	q3[]	q5[+L]	q5[]
j7	q7[+L, +W, +S]	q7[+S]	q9[+S, +L]	q9[+S]	q11[+S, +L]	q11[+S]
j8	q0[-L]	q1[-L]	q2[-L]	q3[]	q1[-W]	q1[-W]
j10	q4[+W]	q5[+W]	q0[+W]	q1[+W]	q4[]	q1[-W]
j12	q1[+L]	q1[]	q3[+L]	q3[-W]	q1[+L, -W]	q1[-W]
j13	q7[+S, +L]	q7[+S]	q9[+L, +S]	q9[-W]	q11[+S, +L]	q7[+S, -W]
j14	q5[+L, +W]	q5[+W]	q3[+L]	q1[+W]	q5[+L]	q1[-W]
j15	q11[+S, +L, +W]	q11[+W, +S]	q9[+S, +L]	q9[+S]	q11[+S, +L]	q11[+S]
j16	q2[-W]	q2[-W]	q2[]	q3[-W]	q0[-W, -L]	q1[-W]
j17	q8[-W, +S]	q9[-W, +S]	q8[+S]	q9[-W]	q6[-W, +S, -L]	q7[+S, -W]
j18	q4[+W]	q1[]	q0[-L, +W]	q1[+W]	q4[-L]	q1[-W]
j19	q10[+W, +S]	q7[+S]	q6[+S, -L, +W]	q7[+S, +W]	q10[+W, +S, -L]	q7[+S, -W]
j20	q1[+L]	q3[-W]	q3[+L, -W]	q3[-W]	q1[-W, +L]	q1[-W]
j21	q3[-W, +S, +L]	q9[-W, +S]	q9[+S, +L, -W]	q9[+S, -W]	q11[+S, +L]	q7[+S, -W]
j22	q5[+W, +L]	q9[-W, +S]	q1[+L, +W]	q3[]	q5[+L]	q1[-W]
j23	q11[+S, +W, +L]	q7[+S]	q9[+L, +S]	q9[+S]	q11[+S, +L]	q7[+S, -W]

Table 8.3: AATS joint actions (1)

Within Table 8.3, we can see that all of the states in the first column are transitions from the initial state of the problem (q0). We can also see that the joint action that is advocated by the initial formulation of this argument is j15 in which speed cameras are

j	q6	q7	q8	q9	q10	q11
j0	q6[]	q7[]	q8[]	q9[]	q10[]	q11[]
j2	q10[+W]	q7[]	q10[+W]	q9[]	q10[]	q11[]
j6	q7[+L]	q7[]	q9[+L]	q9[]	q11[+L]	q11[]
j7	q7[+L]	q7[]	q9[+L]	q9[]	q11[+L]	q11[]
j8	q8[-W]	q9[-W]	q8[]	q9[]	q10[]	q11[]
j10	q10[+W]	q7[]	q10[+W]	q9[]	q10[]	q11[]
j12	q9[+L, -W]	q9[-W]	q9[+L]	q9[]	q11[+L]	q11[]
j13	q9[+L, -W]	q9[-W]	q9[+L]	q9[]	q7[-W, +L]	q11[]
j14	q7[+L]	q9[-W]	q9[+L]	q9[]	q11[+L]	q11[]
j15	q7[+L]	q9[-W]	q9[+L]	q9[]	q11[+L]	q11[]
j16	q8[-W, -L]	q9[-W]	q8[]	q9[]	q6[-W]	q7[-W]
j17	q8[+L, -W]	q9[-W]	q8[]	q9[]	q6[-W]	q7[-W]
j18	q10[+W, -L]	q9[-W]	q6[+W]	q9[]	q10[]	q7[-W]
j19	q10[+W]	q9[-W]	q6[+W]	q9[]	q10[]	q7[-W]
j20	q9[+L, -W]	q9[-W]	q9[+L]	q9[]	q7[+L, -W]	q7[-W]
j21	q7[+L]	q9[-W]	q9[+L]	q9[]	q7[+L,-W]	q7[-W]
j22	q9[+L, -W]	q9[-W]	q9[+L]	q9[]	q7[+L,-W]	q7[-W]
j23	q7[+L]	q9[-W]	q9[+L]	q9[]	q7[+L,-W]	q7[-W]

Table 8.4: AATS joint actions (2)

installed, speeding drivers are prosecuted, drivers reduce their speed, and accidents are reduced. Hence, the target state of this position is q11.

Note, however, that the initial position of the Speed Camera Debate, as posed earlier in the thesis and at the beginning of Section 8.3.3, did not explicitly state that speeding drivers would be prosecuted - it has been assumed by the proponent of the argument (and therefore the argument that "installing speed cameras would not have the desired effect because offenders would not be prosecuted" would be a legitimate objection). In the representation of the Speed Camera Debate in terms of an AATS, the agents relevant to the debate are all explicitly represented. Conversely, when the debate is represented using an argumentation scheme, only the action of one particular agent is explicitly stated (in this case, the government), and the actions of other relevant agents are either assumed (for example, police prosecuting those who speed) or represented differently (for example, drivers reducing their speed, which is represented in the consequences). By representing the debate in terms of an AATS, the debate creators are forced to consider any presuppositions that have been made, whether they be the facts that are true in each state or the actions and actors required to move between the states. In this way it may be possible to anticipate and so take steps to avoid possible objections.

The AATS structure not only allows us to visualise all of the possible transitions from the initial state of the problem, but also transitions from the resulting states to other states if a further joint action is performed. The representation also allows us to see all of the values promoted by reaching these states. This could be useful, for example, to see which action maximises the promotion of identified values whilst avoiding any transitions which demote a set of particularly desirable values.

Having instantiated the AATS, we can now see the range of alternative arguments for action that can be put forward in the current circumstances, each promoting zero or more values. Some of these arguments lead to quite obviously undesirable states of affairs; for example j8, which leads to a situation in which none of the stated values are promoted, and the "Law and Order" value is demoted. However, they are represented in the AATS for completeness, and could conceivably be called upon later in the critical questioning of the argument.

I now consider a range of these arguments and the objections that could be posed against them, in the form of the critical questions associated with the argumentation scheme. To aid visual clarity the consequences and goals are not listed separately, as per the representation of the argumentation scheme in the Parmenides system. The circumstances are also not explicitly stated, as I only consider transitions from state q0. State q0 represents the initial state of the debate, in which the circumstances are always as presented in the initial position of the Speed Camera Debate:

> In the current circumstances *there is a high death toll on UK roads, drivers break the speed limits, the government make money from speeding fines.*

I consider a selection of the 18 arguments that could be generated by considering the transitions from this state (one for each of the joint actions), in order to illustrate a variety of the attacks that can be posed against the arguments.

By way of an example, consider a situation in which the respondent believes that j12 should be carried out in the initial state of q0, thus effectively putting forward the following argument:

Argl: The police should prosecute drivers. This will result in fines being collected from speeding drivers, promoting Government Wealth (Action j2)

A number of the critical questions associated with the argumentation scheme could be posed against this argument, for example:

Arg1Obj1: This will not result in a reduction in the death toll, which is more important than Government Wealth (posing CQ11)

Arg1Obj2: Government Wealth should be raised in ways other than prosecuting drivers (posing CQ7)

Arg1Obj3: Focusing on speeding drivers will reduce the time police spend on more serious crimes (posing CQ9)

Obj1 seems like a reasonably strong objection to the argument, as a government is unlikely to admit that the value of Government Wealth is more important than the value of Saving Lives which would be promoted by reducing the death toll. Meanwhile, Obj2 may be rejected on the grounds that catching speeding drivers is the most cost-effective way of raising government funds. Finally, Obj3 may be rejected by the government on the basis that accidents caused by speeding cost a large number of lives each year, and hence speeding is a serious crime.

Arg2: The police should prosecute drivers, to reach q1 in which speed limits are obeyed, promoting Law and Order. (Action j6)

Note that in the case of Arg2, the "Wealth" value is not promoted because drivers reduce their speed and hence the police do not generate an income as large as that in Arg1. Objections that could be posed against this particular argument are as follows:

Arg2Obj1: Prosecuting speeding drivers will not result in drivers obeying the speed limits (posing CQ2)

Arg2Obj2: Prosecuting drivers will cause anger towards the police, and an increase in other crimes (posing CQ8)

Obj1 could possibly be backed up by statistics, for example a large number of drivers having multiple speeding offences recorded on their driving licenses. Conversely, it could be rejected on the production of statistics to suggest the opposite. Obj2 is likely to be rejected, as there is only a loose connection between motoring offences and other forms of criminality.

Arg3: We should install more speed cameras, to reach q7 in which speed limits are obeyed and accident rates are low. This promotes Law and Order and Saving Lives

(Action j13)

Against which the following objections could be posed:

Arg3Obj1: Drivers will not obey the speed limits (as they are not prosecuted for speeding) (posing CQ2)

Arg3Obj2: Accident rates will not be reduced, as drivers will not reduce their speed (posing CQ17)

Obj1 will probably be sufficient to reject this argument; after all, the knowledge that police are not prosecuting those caught speeding will quickly become widespread and the speed cameras will be of little deterrent to those who break the speed limits. What this does, however, make clear is that the introduction of speed cameras needs to be backed up by an active prosecution policy so that drivers take them seriously. Obj2 is similar, stating that the driver will not uphold his part of the joint action.

Arg4: We should install more speed cameras and prosecute speeding drivers, to reach q5 in which speed limits are obeyed and government wealth is high. This promotes Law and Order and Government Wealth (Action j14)

All of the objections from Arg2 could be posed against this argument, in addition to the following attacks:

Arg4Obj1: If speed cameras are installed and the government prosecute speeding drivers, this will promote Saving the Planet (due to reduced Carbon Dioxide emissions) (CQ10)

Obj1 attacks the justification for action rather than the action itself (because the fact that carrying out an action promotes an additional value is unlikely to be a reason for rejecting the action). In terms of the AATS, it questions whether the transition between the initial state and the consequent state promotes the correct values.

By examining the AATS transition matrix in Figure 8.3 and Figure 8.4, one can see that a large selection of additional arguments are possible, and a variety of the critical questions associated with the scheme can be posed against the actions, transitions and states of the AATS in order to challenge these arguments. Here, I have shown a number of these arguments and attacks in order to illustrate the operation of the AATS structure.

In the next section, I consider how the work of Chapter 6 could inform interactive attacks between argumentation schemes in the structure of an AATS.

8.3.4 Considering the Viability of Attacks Between Schemes

So far in this chapter I have presented the AATS, an existing well-documented structure that has been used to formalise the practical reasoning scheme. If this work is considered in light of the developments I presented in Chapter 6, where I considered how argument schemes could interact in order to support and attack each other, one of the obvious questions that arises is that of whether we can represent argumentation scheme interactions using the AATS structure.

Firstly, I consider two of the argumentation schemes that were used in Chapter 6. If we are to represent attacks of these schemes within the AATS, then it must be possible to represent at least the conclusions of these schemes within the notation supported by the AATS. The two schemes that I will consider are *Argument from Expert Opinion* and *Argument from Cause to Effect*, which have the following conclusions:

Argument from Expert Opinion: Fact A may (plausibly) be taken to be true.

Argument from Cause to Effect: If A occurs then B will (or might) occur.

We see from examination of these conclusions that they have differing representational requirements if we are to consider using the schemes to attack and support parts of the AATS representation of the practical reasoning scheme. For example, to represent the conclusion of the Expert Opinion scheme may not be too difficult, as it simply asserts that truth of a particular proposition (Fact A). Conversely, the Cause to Effect scheme requires the representation of causality between two occurring states.

Consider again the AATS definition given in Section 8.3.1. One can see from this definition that the notation used within the AATS is focused towards the representation of actions, and is unlikely to satisfy the representational requirements of most other argumentation schemes. Hence, schemes that could not be represented using the AATS would be unable to pose attacks against the critical questions within the AATS representation of the practical reasoning scheme.

By way of an example, consider again the "Argument from Cause to Effect" scheme which concludes with a statement which expresses the existence of a causal relationship between the occurrence of two particular states. In Chapter 6, I identified the Cause to Effect scheme as being appropriate for responding to CQ2, CQ8, and CQ9 of the practical reasoning scheme. I now consider the formal definition of these three critical questions in terms of the AATS structure:

CQ2: $\tau(q_x, j_n)$ is not q_y.

CQ8: In the initial state $q_x \in Q$, if agent $i \in Ag$ participates in joint action $j_n \in J_{Ag}$, then $\tau(q_x, j_n)$ is q_y, such that $p_b \in \pi(q_y)$, where $p_a \neq p_b$, such that $\delta(q_x, q_y, v_u)$ is $-$.

CQ9: In the initial state $q_x \in Q$, if agent $i \in Ag$ participates in joint action $j_n \in J_{Ag}$, then $\tau(q_x, j_n)$ is q_y, such that $\delta(q_x, q_y, v_w)$ is $-$, where $v_u \neq v_w$.

We see that the formulation of these critical questions is rather complex. Furthermore, there is no specific representation of a causality within the AATS, and hence the causal dispute raised by each of these critical questions differs in formulation. For this reason, formalising the conclusion of the Cause to Effect scheme in such a way that it is able to pose these critical questions, without significant modification to the AATS notation, would not be straightforward.

In this section I have discussed the interaction of other argumentation schemes with the practical reasoning scheme in the context of an AATS. I have justified the unsuitability of the current AATS formalism in representing such interactions formally, and considered some of the additional formalisms that would be required to enable attacks to take place through such interactions. Although developing a formalism that would enable a range of argumentation schemes to participate in the formulation and challenge of arguments within the AATS would undoubtedly be both interesting and contributory to the research field, the complexity of the task places it beyond the scope of this thesis.

8.3.5 Software Implementation

The motivation given for the investigation into the formalisation of argumentation schemes was that it enables automated reasoning of schemes using computational tools. In this section, I discuss some of the previous other work to develop such a tool.

The first piece of work that I discuss is that of Chorley *et al.* [36], who describe a particular practical reasoning problem in terms of the states that characterise the problem and the values promoted by moving between these states. They then go on to develop an AATS representation of the problem, and eventually implement a software tool to automatically create part of the AATS. The second paper which I examine is by Nawwab *et al.* [112]. The authors describe a method of decision making which combines AATS, argumentation schemes, and Argumentation Frameworks in order to reach decisions on acceptable actions for a particular agent to execute. A practical reasoning problem is described, which illustrates the usefulness of the approach. The work described in [112] provides a potentially useful framework for future software developments, which could utilise all three of these methods of argument representation and analysis (AATS, argumentation schemes, and Argumentation Frameworks).

The practical reasoning problem described by Chorley *et al.* in [36] is based around two agents, Hal and Carla, who are both diabetic. Hal has lost his insulin supply and urgently needs to find some in order to stay alive. The only way in which he can obtain insulin is to break into the home of Carla in order to make use of her insulin supply. The debate is based around the values of life of the agents (promoted when they take insulin, and hence do not die), and their wealth.

Chorley *et al.* develop an AATS representation of this problem in terms of the practical reasoning scheme, before describing a software application that has been developed to support this process. The software application takes a description of the practical reasoning problem, in terms of the possible states, agents and their possible actions, joint actions, and values applicable to the scenario. Their software tool then creates the transition matrix for the initial state of interest of the problem. Given the inputs described above, the program can also compute the values promoted or demoted by carrying out each action, and generate arguments for performing or not performing an action based on the values promoted or demoted by the transitions. The program is then able to pose critical questions against each argument in order to select the justified action.

However, this software tool is developed for use with a single practical reasoning problem. Future research in this area could involve creating a software application that can create AATS structures for any practical reasoning problem, given the appropriate inputs. One can imagine how the future work proposed in Section 8.3.4, on the interaction of argumentation schemes within an AATS, could be developed into software tools which both allow mapping of the argument space, and also automatically evaluate actions according to the attacks that can be posed against their justifications by other schemes. Such a software tool could be standalone, or could be designed for use in conjunction with the Parmenides system. For example, before creating a debate in the Parmenides system, the debate creator could instantiate an AATS by inputting the details of the argument (states, agents, joint actions, etc.) to the software tool. The tool would then produce the transition matrix, along with the values promoted by each transition, in order for the debate creator to see all of the possible arguments that could be formulated in the current situation. The software tool could also allow the debate creator to see all of the attacks that could be posed against these arguments (possibly using different schemes). Thus, the debate creator could use such a tool to perform automated analysis of arguments before they are even made available to the public.

Outside of Parmenides, there are a range of situations in which it would be useful to develop software which can use the structure of an AATS in order to reason over practical problems. As discussed in Chapter 4, software agents increasingly rely on the ability to make decisions on the "best" course of action to carry out in a given situation.

By enabling such software agents to perform automated reasoning using the AATS formalism of the practical reasoning scheme, an agent can evaluate the relative merits of carrying out each possible action. Given the AATS transition matrix, an agent could reason over which action to select according to a set of criteria (for example, promotion of a specific value, promotion of the maximum number of values, and/or the desire to reach a certain state) in order to achieve the agent's specific aims and aspirations.

In [112], Nawwab *et al.* consider how the arguments arising from an AATS can be organised into a Value-based Argumentation Framework, the method of argument visualisation and evaluation used in the Parmenides System. By merging these two approaches, one can allow reasoning over practical problems using the AATS in order to develop the set of available actions and state transitions, and evaluation of the arguments using the semantics of a VAF. The practical reasoning problem described in this paper is based around a university in which three PhD students apply for funding to go to a conference, but there is only enough funds for two of the students to go. The problem is first instantiated in terms of an AATS, in order to determine the possible actions that could be taken to decide which students should go.

By examining the critical questions associated with the practical reasoning argumentation scheme, the possible attacks on (and between) each argument are identified. After identifying all of the attacks, the problem can be represented in terms of a Value-based Argumentation Framework, which can then be evaluated in order to determine the acceptable arguments.

The method described in this paper for formulating, building and evaluating practical reasoning problems could provide a solid foundation for the development of software tools which support the whole debate life cycle; from determining the arguments applicable to a particular situation, to evaluation of the arguments.

8.4 Summary

In this Chapter I have considered how argumentation schemes, discussed extensively throughout the earlier chapters of this thesis, can be formalised in order to enable software applications to perform automated reasoning using the schemes. I have examined how this could assist in the creation of arguments in systems such as Parmenides.

I started by considering an existing formal representation of the practical reasoning scheme in terms of an Action-based Alternating Transition System (AATS). I examined the notation used to represent the scheme and its critical questions, before instantiating the AATS with a particular example debate based around the installation of speed cameras on UK roads. I considered some of the attacks that could be made on the debate through critical questioning of the AATS.

In the final sections of the chapter, I explored potential future research avenues: Firstly, in Section 8.3.4 I considered how other argumentation schemes could be represented in terms of the AATS, in order to allow attacks through arguments instantiated using these schemes. I then went on to discuss existing attempts to develop software applications that make use of the AATS structure, and how the work presented in this chapter could inform future developments of computational tools for automated reasoning over practical problems using argumentation.

Chapter 9

Evaluation

9.1 Overview

In Chapter 5 and Chapter 7, I described the Parmenides System that I have implemented. In this section, I evaluate Parmenides through two distinct evaluations, each of which targets a different audience with a different debate. I present the results of the evaluation and discuss how these results meet the objectives of Parmenides, and how they could influence future developments.

9.2 Description of Evaluations

The evaluation of Parmenides was subject to a number of important considerations regarding the type and quality of feedback which I wanted to obtain.

The first consideration was the type of audience required for the evaluation. As the Parmenides System is intended for the purpose of gathering public opinion in e-Democracy, the system must be suitable for use by a wide range of people who do not have any prior knowledge of the system or the structure on which the system is based.

The second consideration was that I would need some sort of incentive for people to participate in an evaluation. If a system such as Parmenides were to be piloted by a government, the fact that the government would see the results of a debate and possibly act upon these results is likely to be a factor in motivating users to participate in such a debate. In my evaluations, no policy change will occur as a result of the opinions gathered using the system and hence the incentive for the average citizen to participate in the evaluation is fairly low. In order to overcome this problem, I would need to choose the target group such that they would have an interest in the work and would participate in the evaluation for this reason.

The third consideration was that I wanted the evaluation groups to not only interact with the system, but also to provide useful feedback. Thus, I would need to present the evaluation to audiences who are likely to be inspired to give feedback which would give an insight into the effectiveness of the system.

Finally, I would need to carefully consider the debate to be used during the evaluations. A debate which is not particularly interesting or relevant to the target group is not likely to elicit a high number of responses; however, a debate which is too emotive could result in users giving biased feedback of the system due to their feelings on the topic of debate.

Two separate evaluations were carried out on the Parmenides system, each targeted towards a different audience. Each of the evaluations was also based on a separate topic of debate within the system. The evaluations were as follows:

- **Evaluation 1:** This evaluation was targeted at PhD students within the Department of Computer Science at The University of Liverpool. I decided to use this target group as they would find it easy to contact me if there were any problems with the system or they needed any help in interacting with it. Although this target group are all working in Computer Science, most are not working in argumentation and hence can be thought of as "laypersons" with regards to their understanding of the system's underlying structure.

- **Evaluation 2:** For the second evaluation of the system, the target group was academics working in the research area of argumentation. Although these people are certainly not "laypersons", the objective of the second evaluation was to solicit feedback on the system from a group of people who were knowledgeable about the underlying structure and the research area in general.

The user's interaction with the system consisted of three phases: Firstly, the user is given information about the evaluation. This information is provided in the form of an email that is sent out to the target audience to solicit responses (with the exception of Evaluation 2, Phase 2, where the information was provided in person). The user is provided with a link to the Parmenides system, after clicking which he is taken to a further page of information about how the system works. Secondly, the user submits his opinion on the topic of debate. Thirdly, the user is asked to fill in an electronic questionnaire after he finishes interacting with the system. The questionnaire solicits feedback on how the user felt about the system.

It is the evaluation questionnaire presented to users of the system which I describe next.

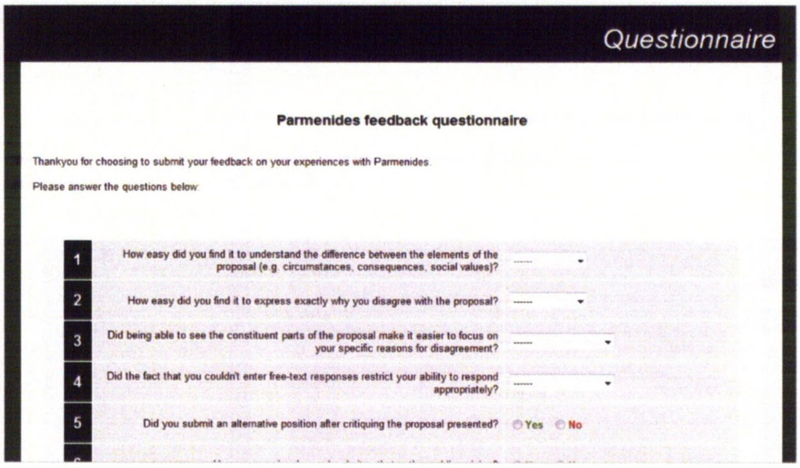


Figure 9.1: Parmenides evaluation - Questionnaire presented to users

9.3 Evaluation Questionnaire

The evaluation questionnaire was designed to gather feedback from each participant after he had submitted his opinion on the topic of debate. The questionnaire aimed to discover how easy or difficult it was for the user to understand the underlying structure of the system, how much the user enjoyed interacting with Parmenides, and whether the user would use Parmenides again in future. Ultimately, the aim of the questionnaire was to establish in how far the system met its objectives, and to develop ideas for future enhancements of Parmenides and online opinion gathering systems in general.

The questionnaire is presented to users after they finish interacting with the system. Users are not obliged to complete the questionnaire - their response to the debate is saved even if the user closes his browser window before submitting the questionnaire. The questionnaire interface is shown in Figure 9.1.

The questionnaire consisted of ten questions, which were as follows:

1. How easy did you find it to understand the difference between the elements of the proposal (e.g. circumstances, consequences, social values)? (Very easy, Easy, Neutral, Difficult, Very difficult)

2. How easy did you find it to express exactly why you disagree with the proposal? (Very easy, Easy, Neutral, Difficult, Very difficult)

3. Did being able to see the constituent parts of the proposal make it easier to focus on your specific reasons for disagreement? (Yes definitely, Yes a little, Neutral, No not noticeably, No definitely not)

4. Did the fact that you couldn't enter free-text responses restrict your ability to

respond appropriately? (Yes definitely, Yes a little, Neutral, No not noticeably, No definitely not)

5. Did you submit an alternative position after critiquing the proposal presented? (Yes, No)

   If Yes to Q5:

   (a) Did you feel you were able to express your opinion sufficiently? (Yes definitely, Yes a little, Neutral, No not noticeably, No definitely not)

   If No to Q5:

   (a) Please tell us why you didn't submit an alternative position: (Did not have an alternative position in mind, Did not have time, Did not see the option, Did not understand how to use it, Other)

6. Have you previously used websites that gather public opinion? (Yes, No)

   If Yes to Q6:

   (a) Which kinds of website have you used? (e-Petitions, News story responses, Individual blog responses, Opinion polls, Online surveys, Item review websites, Other)

   (b) How often (on average) do you use such websites? (Daily, Weekly, Fortnightly, Monthly, Less than Monthly)

   (c) How does Parmenides compare to these other websites, overall? (Much better, Slightly better, About the same, Slightly worse, Much worse)

   If No to Q6:

   (a) Has the Parmenides website encouraged you to share your opinions more often? (Yes definitely, Yes a little, Neutral, No not noticeably, No definitely not)

7. Would you use Parmenides again? (Yes, Unsure, No)

8. Would you use Parmenides regularly to participate in opinion polls that are relevant to your life? (Yes, Unsure, No)

9. Do you have any other suggestions or comments related to Parmenides?

10. Do you have any suggestions or comments related to online opinion gathering systems in general?

At the end of the questionnaire, users are given the opportunity to provide their name and e-mail address, in case they would like a response to the comments that they have provided in response to the questionnaire. These details are optional - the user has the option to remain completely anonymous. The option of complete anonymity was particularly important during this evaluation, to ensure that the users felt free to answer all of the questions honestly.

I now describe each evaluation in turn, including the results obtained from the above described questionnaire in each case.

9.4 Evaluation I

The target group of the first evaluation were PhD students within the University of Liverpool's Computer Science Department. The main aim of this evaluation was to determine the opinions of people who had been exposed to the system, rather than to determine how likely people are to use the system. It was for this reason that I selected this particular sample group, as they are people who are likely to be sympathetic to the requirement to evaluate software systems and thus more likely to participate in the evaluation. The other motivations for choosing this particular group can be summarised as follows:

- **Accessibility** - The group were accessible to me, and thus could approach me directly with any comments or feedback related to the system
- **Diversity** - The PhD students within the Computer Science Department are a wide range of ages, a variety of nationalities, and thus represent a wide and varied sample
- **Familiarity** - The vast majority of the target group are colleagues that are known to me, and thus more likely to participate in the evaluation than if I had 'cold contacted' a group of people

In addition to the evaluation target group, I also had to consider the debate that was to be used for the evaluation. It had to fulfill a number of criteria: Firstly, the debate must not cause unrest within the Computer Science department - thus any debate which centred around policy within the department itself was to be avoided. Secondly, the debate should be of relevance and interest to the target audience, namely PhD students.

I decided to use a debate based around the University policy of allowing laptops to be used in lecture theatres, whilst banning mobile phone usage. I chose this debate as I was confident that it would be of interest to PhD students, all of whom have previously been students and many of whom aspire to become lecturers. I also knew from previous conversations with my colleagues that it would provoke a range of different reactions

- from those who believe that laptops are a useful educational tool during lectures to those who believe that they are an unnecessary distraction.

The debate that I used, named "The Laptops in Lecture Theatres Debate", comprised the following justifications for the action of "Ban laptops in lecture theatres":

1. In the current situation *University rules do not ban laptops in lecture theatres* and *University rules ban the use of other entertainment devices in lecture theatres.* We should *Ban laptops in lecture theatres.* Our goals are to *Make the rules consistent.* This will promote *Consistency.*

2. In the current situation *University rules do not ban laptops in lecture theatres* and *Members of the audience using laptops distracts the lecturer.* We should *Ban laptops in lecture theatres.* Our goals are to *Allow the lecturer to concentrate on giving their presentation.* This will promote *Respect.*

3. In the current situation *University rules do not ban laptops in lecture theatres* and *Using laptops during lectures is not beneficial to learning.* We should *Ban laptops in lecture theatres.* Our goals are to *Increase audience concentration on the lecture.* This will promote *Personal learning.*

4. In the current situation *University rules do not ban laptops in lecture theatres* and *Using laptops during lectures distracts other members of the audience.* We should *Ban laptops in lecture theatres.* Our goals are to *Reduce distraction of other audience members.* This will promote *Other people's learning.*

The debate interface was, as per all of the debates within the Parmenides system, created with the Debate Creator and hence follows the same structure described in Section 5.4. The only minor modifications made to this structure were, firstly, to add a link to the questionnaire at the end of the debate and, secondly, to add an introductory page that is shown to the user before they enter the system. The introductory page gives some details of Parmenides itself, how it works and the purpose of the system, as well as some general details of the evaluation. It also re-assures the user that all submissions to the system will remain anonymous, and includes a privacy policy (see Figure 9.2) which details the precise information that is collected from the user and the reasons for collecting such data.

In order to invite PhD students to participate in the debate, I sent an email to the university departmental mailing list of PhD students. This was followed up with a further email reminding students about the debate around one week before the proposed evaluation ending date.

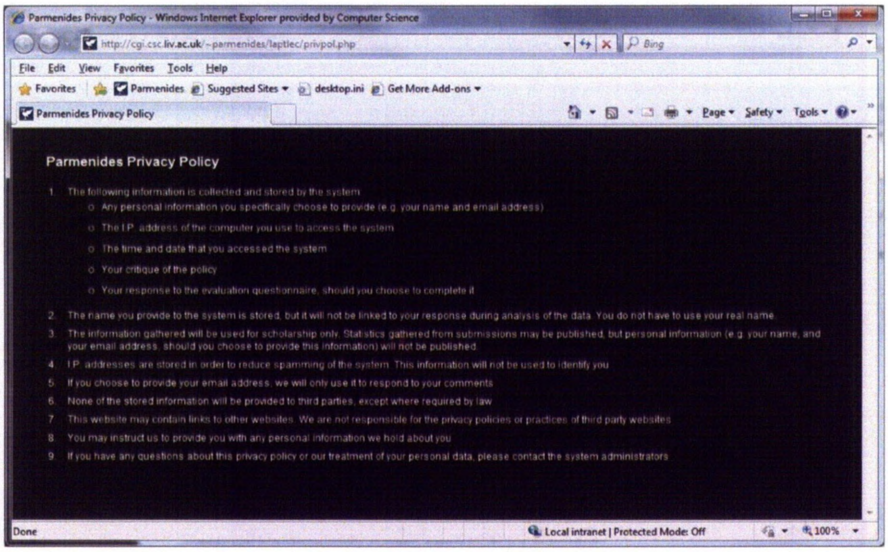


Figure 9.2: Parmenides evaluation - Privacy Policy

9.4.1 Evaluation Results

9.4.1.1 Quality and Quantity of Results

As a first step towards determining the quantity and quality of the response to the evaluation debate, I created a PHP-based webpage to extract some of the key data from the database. Importantly, as this page displayed some confidential information related to users, I applied password protection to the page to ensure that it could not be viewed by unauthorised parties.

The PHP page showed the name entered by the user, the IP of the computer used to respond, whether or not he agreed with the initial position, whether a critique was submitted, whether an alternative position was submitted, and whether the questionnaire at the end of the system was completed. Clicking the relevant column headers allows the entries to be sorted according to the particular column chosen. Part of the analysis webpage is shown in Figure 9.3, although some of the information presented on this page has been blurred to protect the identities of the debate participants.

This summary view of user submissions allowed me to identify entries which were likely to be "spam" contributions. These were typically contributions that were submitted from the same IP address within a short period of time, often with similar aliases given. For the purposes of the evaluation, sifting out entries using a manual method such as this was not too difficult or time consuming. In a real-world implementation of Parmenides in which a large volume of users would be interacting with the system, it may be beneficial to integrate Parmenides with some other form of authentication

Result Analysis

ID	Name	IP	Agree?	Critique?	OwnOpinion?	Questionnaire?
30	[illegible]	[illegible] 91.1	No	Yes	No	Yes
31	[illegible]	[illegible] 125.1	Yes	No	No	No
32	[illegible]	[illegible] 125.1	No	Yes	No	Yes
29	[illegible]	[illegible] 232.1	No	Yes	No	No
27	[illegible]	[illegible] 66.1	No	Yes	No	Yes
25		[illegible] 46.180	No	Yes	No	Yes
26	[illegible]	[illegible] 66.1	Yes	No	No	No
33	[illegible]	[illegible] 78.2	Yes	No	No	No
34		[illegible] 232.1	No	Yes	No	No
41		[illegible] 126.1		No	No	No
40		[illegible] 126.1	No	Yes	No	No
38	[illegible]	[illegible] 229.1	No	Yes	No	Yes
37	[illegible]	[illegible] 231.1	Yes	No	No	No

Figure 9.3: Evaluation I - Webpage displaying summary information about participants

system which ensures that users can only submit an opinion once. I discuss this issue further in Section 10.3.1.

After removing entries from the database which were obviously non-genuine, I was left with 32 responses from a total of 36 PhD students who received the email regarding the evaluation. Notably, some users appeared to agree with the initial position put forward, but then re-enter the system and disagree with it in order to be given the opportunity to critique the position (when a user agrees with the initial position as presented then his interaction with the system ends, as described in Chapter 5). As such users may have provided useful feedback on the questionnaire, I did not remove these duplicate entries from the system.

Of the responses received, exactly 50% (sixteen) users agreed with the initial position as presented. Three such users then re-entered the system and submitted another response in which they disagreed with the initial position. Of the sixteen users who provided a critique of the initial position and thus were eligible to complete the questionnaire, ten questionnaire responses were received. Only two users went on to submit an alternative position after critiquing the initial position that they were presented with. It is interesting that few users went on to submit an alternative position; the reasons users gave for not submitting an alternative position are elaborated in the questionnaire responses in Section 9.4.1.2. A full account of the responses received to the evaluation are provided in Appendix A.

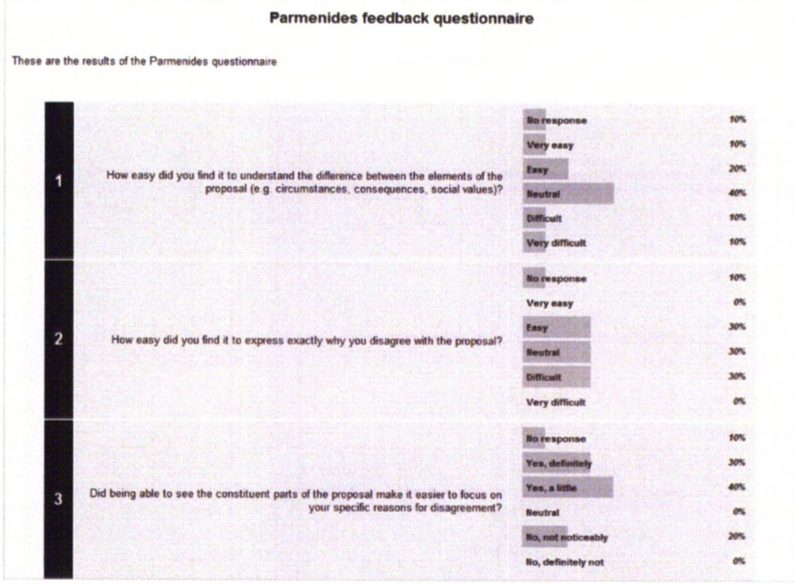


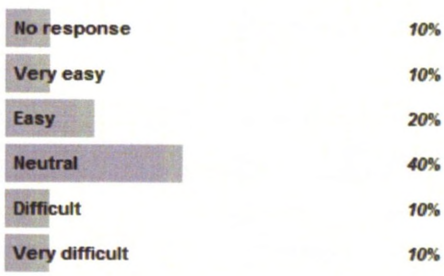
Figure 9.4: Parmenides evaluation - Webpage displaying results of questionnaire

9.4.1.2 Results of Questionnaire

As briefly discussed above, of the users who submitted a critique of the initial position, ten users went on to complete the questionnaire. In order to analyse the results of the survey, I created a PHP-based page which collated data from the database of submissions and analysed it in terms of bar charts. A screenshot of the website is given in Figure 9.4.

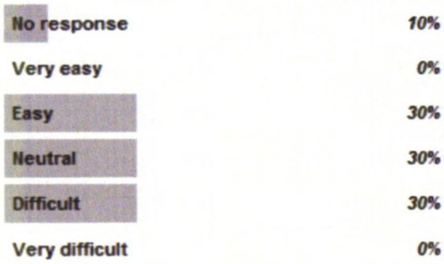
The results of the questionnaire were as follows:

1. How easy did you find it to understand the difference between the elements of the proposal (e.g. circumstances, consequences, social values)?



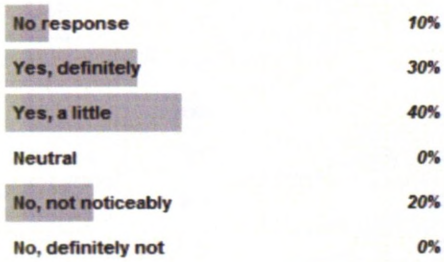
(n=10)

2. How easy did you find it to express exactly why you disagree with the proposal?



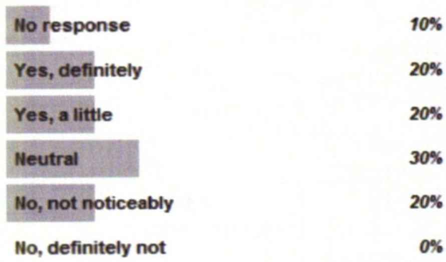
(n=10)

3. Did being able to see the constituent parts of the proposal make it easier to focus on your specific reasons for disagreement?



(n=10)

4. Did the fact that you couldn't enter free-text responses restrict your ability to respond appropriately?



(n=10)

5. Did you submit an alternative position after critiquing the proposal presented?

(n=10)

If No to Q5:

(a) Please tell us why you didn't submit an alternative position:

No response	0%
Did not have an alternative position in mind	44%
Did not have time	44%
Did not see the option	0%
Did not understand how to use it	0%
Other	11%

(n=9)

6. Have you previously used websites that gather public opinion?

No response	20%
Yes	50%
No	30%

(n=10)

If Yes to Q6:

(a) Which kinds of website have you used?

Petitions	60%
News story responses	20%
Individual blog responses	40%
Opinion polls	100%
Online surveys	80%
Item review websites (e.g. Ciao)	60%
Other	0%

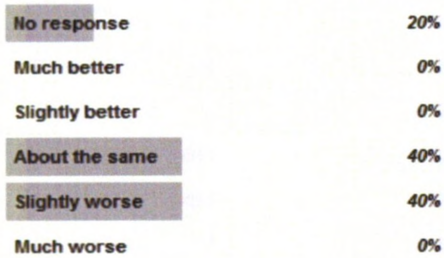
(n=5)

(b) How often (on average) do you use such websites?

No response	0%
Daily	40%
Weekly	0%
Fortnightly	0%
Monthly	20%
Less than monthly	40%

(n=5)

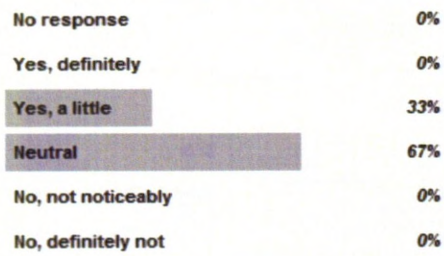
(c) How does Parmenides compare to these other websites, overall?



(n=5)

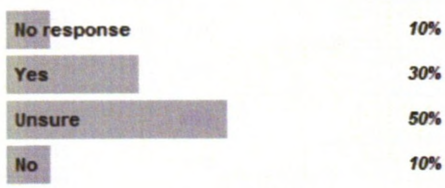
If No to Q6:

(a) Has the Parmenides website encouraged you to share your opinions more often?



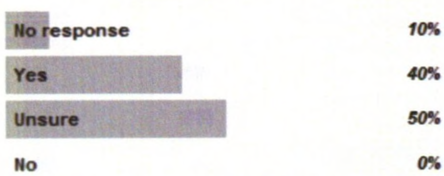
(n=3)

7. Would you use Parmenides again?



(n=10)

8. Would you use Parmenides regularly to participate in opinion polls that are relevant to your life?



(n=10)

9.4.1.3 Analysis of Results

The response rate to the first evaluation was good, with 32 responses received from a total of 36 PhD students who received the invitation to participate. Of the users who did not agree with the initial position, 100% provided a critique of the position, but only two (13%) of users went on to provide an alternative position. The questionnaire asked users exactly why they did not provide an alternative position. 44% of users said that they did not have an alternative position in mind, which could indicate that the initial position given was good - as it did not leave any details missing that users felt they needed to disclose. A further 44% of users indicated that they did not have enough time to submit an alternative position.

With regards to the critique section of the website, there was a variety of responses when users were questioned about whether they understood the difference between the constituent parts of debates within the system (i.e. circumstances, consequences, etc.). This perhaps indicates that the system requires some additional supporting information to detail the different elements that constitute a debate and the difference between these elements. For example, users could have the option of viewing a run-through of an example debate before using the system. This could also be supplemented by a web-based video.

Users also varied in their responses when asked how easy they found it to express why they disagreed with the initial position, with 30% stating that it was easy, 30% being neutral, and 30% stating that it was difficult. Reassuringly, no users thought that it was "Very difficult". The reason for the variety of responses could be the different reasons that respondents had for disagreeing with the position. It is possible that some users felt that the structure imposed on debates impaired their ability to be as expressive as they would otherwise like - I acknowledge this as a restrictive but necessary trade-off of the Parmenides system at its current stage of development. Indeed, when asked whether the inability to provide free-text responses restricted their ability to respond appropriately, 40% said Yes, with 30% remaining neutral.

As discussed in Chapter 5, one of the main advantages of the Parmenides system is the granularity of the debate structure, which allows positions to be broken down into their constituent parts to enable the exact reasons for disagreement to be pin-pointed. Encouragingly, when questioned, 70% of users said that being able to see the constituent parts of the proposal did make it easier to focus on their reasons for disagreement.

When asked whether they had previously used websites for gathering public opinion, 50% of users said that they had. Of these users, 100% had used Opinion polls, 80% had used online surveys, and 60% had used e-Petitions. 40% of users state that they use opinion gathering websites on a daily basis. The fact that half of the respondents had previously been exposed to opinion gathering websites indicates that their responses to the Parmenides questionnaire are likely to be based on comparisons with such systems. I see this as a positive point, as Parmenides was designed to overcome some of the problems with such systems whilst retaining a similar degree of expressivity and usability.

Finally, users were asked whether they would use Parmenides regularly to participate in opinion polls that were relevant to their lives. 40% of users said that they would, whilst 50% of users said that they were unsure. If users saw that the results of opinions gathered using the system were taken into consideration by the government (or other authoritative body) then it is possible that users would be more inclined to participate in debates.

A further discussion of the evaluation process as a whole is given in Section 9.6. Next, I describe the second evaluation and the results obtained.

9.5 Evaluation II

After completing the first evaluation of the system, I conducted a second evaluation in order to compare and contrast the results obtained during the initial evaluation. For this second evaluation, the target group chosen was academics working in the area of argumentation. This target group was chosen for a number of reasons:

- **Knowledge** - The group has some knowledge of argumentation and thus had some pre-existing idea of how systems such as Parmenides work and why they are implemented. I hoped that this would lead to high quality feedback regarding the system.
- **Diversity** - The people within the group are from a wide variety of institutions, nationalities, and ages and thus represent a reasonably diverse set of opinions.

In contrast to the target group of PhD students selected for the first evaluation, this group were not as well known to me. However, as they were all working within the research area of argumentation, I hoped for a reasonable level of response. One of the important factors in developing a system that is intended for use in e-Democracy is that it should be easy for laypersons to understand and use. This objective was tested by the target group of the first evaluation, whereas the aim of this second evaluation was to get feedback from fellow academics on the quality of engagement provided by the system.

The second evaluation consisted of two separate phases; the first phase involved soliciting feedback through email. The selected group of academics were sent an email asking them to participate in the evaluation of the system (as per Evaluation I). To participate in the debate, respondents simply needed to click on a hyperlink provided in the email. The second phase of the evaluation was carried out during the software demonstration session of the conference "Computational Models of Argument 2010" (COMMA 2010) in September 2010.

During the second phase of the evaluation, an administrator with knowledge of the Parmenides system was present in order to encourage participation in the evaluation and to answer any queries that users had about the system and how it worked.

By utilising these two separate phases of the evaluation, I was able to compare response rates between soliciting opinion through email and soliciting opinion "in person". This goes some way to inform the issue of the best method(s) of encouraging participation in systems such as Parmenides. It also allowed me to determine whether those who were allowed to use the system with the guidance of a human administrator were able to interact with the system more effectively than those who used it with only web-based guidance.

The debate used in the second evaluation was a slightly modified version of the debate used during the first evaluation, based around the use of laptops in research conference presentations. The advantage of using a similar debate is that the results of the evaluations can be compared more directly, as both target groups were using the system to respond to similar (or in some cases identical) questions.

The justifications that comprise the modified debate are as follows. The debate, in accordance with the practical reasoning argumentation scheme which is based around action proposals, proposes that the use of laptops in conference presentations should be banned:

1. In the current situation *Those who use laptops are not concentrating on the presentation.* We should *Ban the use of laptops during conference presentations.* Our goal is to *Increase audience concentration on the talk.* This will promote *Personal learning.*

2. In the current situation *Using laptops during conference talks distracts other members of the audience.* We should *Ban the use of laptops during conference presentations.* Our goal is to *Reduce distraction of other audience members.* This will promote *Other people's learning.*

3. In the current situation *Members of the audience using laptops distracts the speaker.* We should *Ban the use of laptops during conference presentations.* Our goal is to *Allow the speaker to concentrate on giving the presentation.* This will promote *Respect.*

The debate was again presented to users with the same debate interface, introduction pages and evaluation questionnaire that was presented to users of the first evaluation. I decided to use precisely the same questionnaire questions in order to allow direct comparison of the results of both evaluations.

In order to advertise the evaluation to users I chose to send out a simple email to participants' email addresses. As per the first evaluation, this was followed up with a further email as the deadline for participating in the debate approached.

9.5.1 Evaluation Results

9.5.1.1 Phase 1 - Quality and Quantity of Results

As described above, the first phase of this evaluation involved targeting academics via email. Respondents were asked to simply click a link within the email in order to load the debate within the Parmenides system. In total, emails were sent to thirty academics working within argumentation at twenty unique institutions worldwide. Of the thirty emails sent out, fifteen responses were received (indicating that the response rate was around 50%).

Although this was somewhat lower than the number of responses that I would have liked to received, it demonstrates the difficulties in encouraging participation in systems such as Parmenides. Of course, if the results of the debate were to be used to influence any official policy regarding the topic of debate, then the response rate may conceivably be somewhat higher than a debate used purely for evaluation purposes.

The full list of respondents is illustrated in Figure 9.5. Some duplicate responses were removed from the database prior to analysing the results, as well as any users entered for test purposes. The remaining users shown in this figure are believed to be unique genuine respondents.

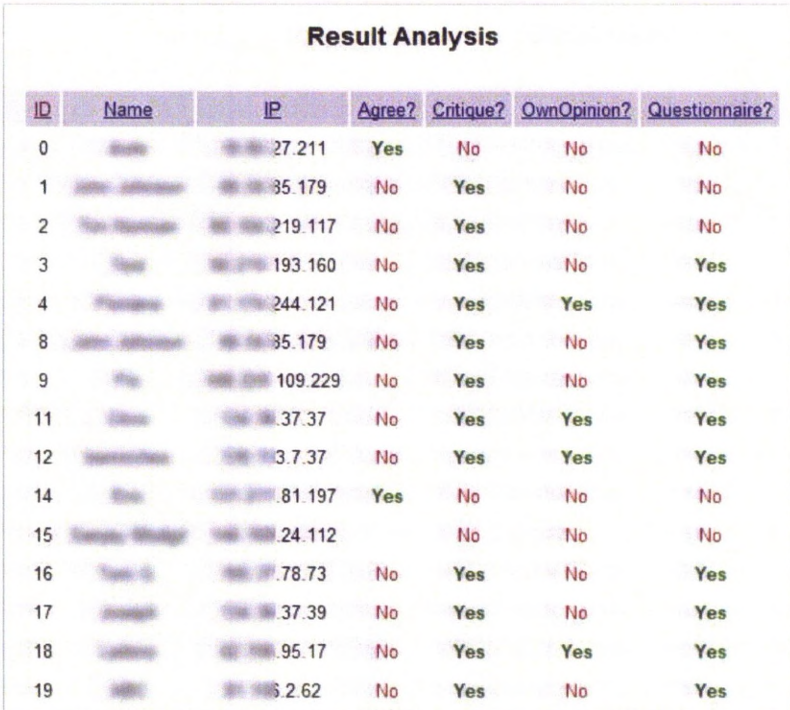
From the information presented in Figure 9.5, one can deduce that two users agreed with the proposal to ban the use of laptops in conference presentations (approximately 87% of respondents therefore disagreed with this position). The users who disagreed with the position are then given the opportunity to provide a critique, in addition to an alternative action proposal. An alternative proposal was provided by four users (33% of the users who were given the opportunity to do so). This is a slight improvement on the percentage of alternative proposals given by users in the first evaluation (13%).

Response to the questionnaire was also good, with ten responses from a potential twelve users who were given the opportunity to complete the questionnaire. The high response rate to the questionnaire could be related to the work area of the respondents; as they work in the area of argumentation they are likely to have strong opinions on the system. The response to the questionnaire is given in the next section.

A full account of the responses to the debate is provided in Appendix A.

9.5.1.2 Phase 1 - Results of Questionnaire

Of the twelve users who participated in the debate, ten went on to provide a response to the questionnaire. As per the first evaluation, I made use of a PHP-based website



Result Analysis

ID	Name	IP	Agree?	Critique?	OwnOpinion?	Questionnaire?
0	[illegible]	[illegible]27.211	Yes	No	No	No
1	[illegible]	[illegible]35.179	No	Yes	No	No
2	[illegible]	[illegible]219.117	No	Yes	No	No
3	[illegible]	[illegible]193.160	No	Yes	No	Yes
4	[illegible]	[illegible]244.121	No	Yes	Yes	Yes
8	[illegible]	[illegible]35.179	No	Yes	No	Yes
9	[illegible]	[illegible]109.229	No	Yes	No	Yes
11	[illegible]	[illegible].37.37	No	Yes	Yes	Yes
12	[illegible]	[illegible]3.7.37	No	Yes	Yes	Yes
14	[illegible]	[illegible].81.197	Yes	No	No	No
15	[illegible]	[illegible].24.112		No	No	No
16	[illegible]	[illegible].78.73	No	Yes	No	Yes
17	[illegible]	[illegible].37.39	No	Yes	No	Yes
18	[illegible]	[illegible].95.17	No	Yes	Yes	Yes
19	[illegible]	[illegible]5.2.62	No	Yes	No	Yes

Figure 9.5: Evaluation II, Phase I - Webpage displaying summary information regarding submissions

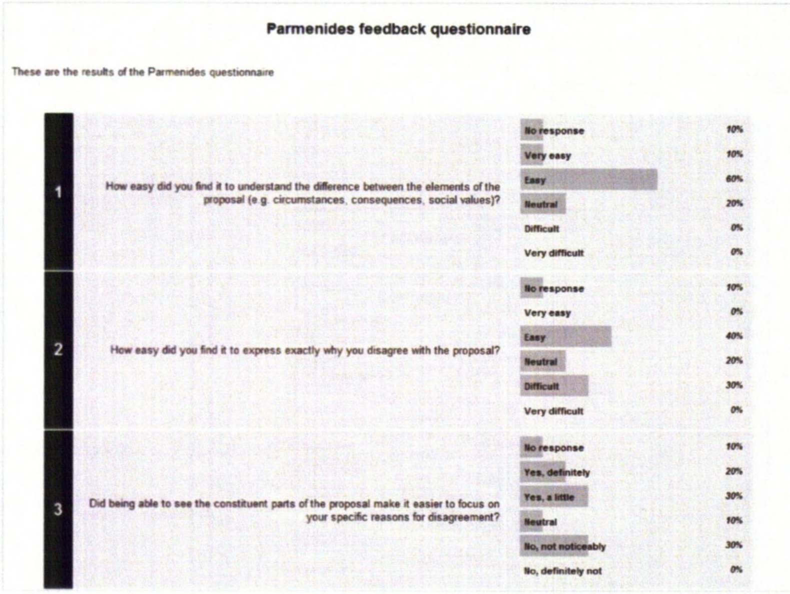
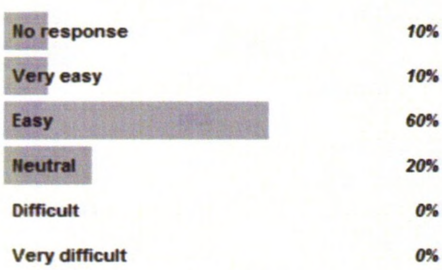


Figure 9.6: Parmenides Evaluation II - Webpage displaying results of questionnaire

which I created in order to analyse the results in terms of bar charts. A screenshot of the website is given in Figure 9.6.

The results of the questionnaire were as follows:

1. How easy did you find it to understand the difference between the elements of the proposal (e.g. circumstances, consequences, social values)?



(n=10)

2. How easy did you find it to express exactly why you disagree with the proposal?

No response	10%
Very easy	0%
Easy	40%
Neutral	20%
Difficult	30%
Very difficult	0%

(n=10)

3. Did being able to see the constituent parts of the proposal make it easier to focus on your specific reasons for disagreement?

No response	10%
Yes, definitely	20%
Yes, a little	30%
Neutral	10%
No, not noticeably	30%
No, definitely not	0%

(n=10)

4. Did the fact that you couldn't enter free-text responses restrict your ability to respond appropriately?

No response	10%
Yes, definitely	10%
Yes, a little	50%
Neutral	0%
No, not noticeably	30%
No, definitely not	0%

(n=10)

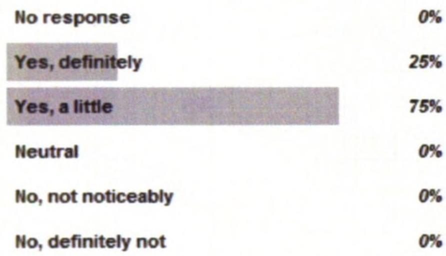
5. Did you submit an alternative position after critiquing the proposal presented?

No response	10%
Yes	40%
No	50%

(n=10)

If Yes to Q5:

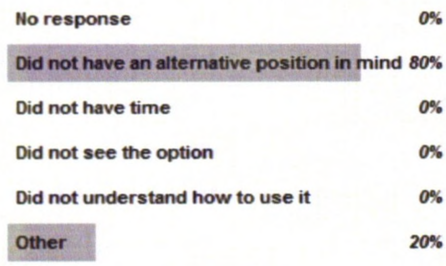
(a) Did you feel you were able to express your opinion sufficiently?



(n=4)

If No to Q5:

(a) Please tell us why you didn't submit an alternative position:



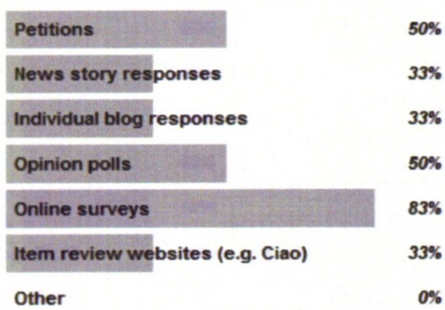
(n=5)

6. Have you previously used websites that gather public opinion?

(n=10)

If Yes to Q6:

(a) Which kinds of website have you used?

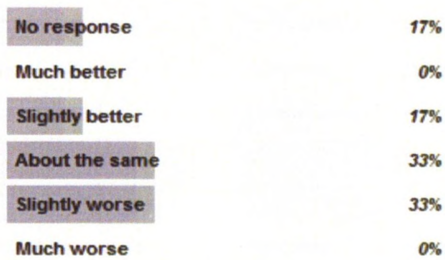


(n=6)

(b) How often (on average) do you use such websites?

(n=6)

(c) How does Parmenides compare to these other websites, overall?



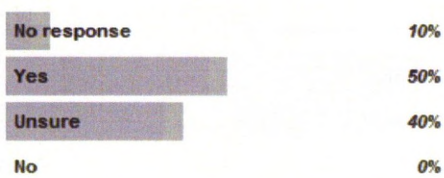
(n=6)

If No to Q6:

(a) Has the Parmenides website encouraged you to share your opinions more often?

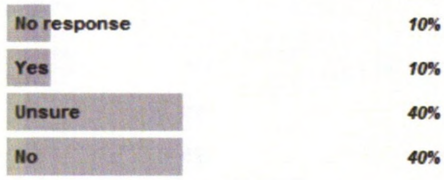
(n=3)

7. Would you use Parmenides again?



(n=10)

8. Would you use Parmenides regularly to participate in opinion polls that are relevant to your life?



(n=10)

In addition to the questionnaire multiple-choice responses, a wealth of useful responses were received to the free-text questions posed to users. These are detailed below, and I respond to each of the points raised in Section 9.5.1.6.

- **Do you have any other suggestions or comments related to Parmenides?**

  1. Why did you not explore the use of the value-based arg model to support on-line dialogue? The way the questionnaire is structured tends to force the user into a specific set of values and a specific argument for a proposition. Why not explore how a system can help someone form such a structure. So, you may provide a list of values that are relevant to the topic, ask which are promoted/demoted by a specific action, allow the user to explore the effects of certain actions, etc., and, through that, enable the user to form an argument that can be put into a debate. It would then be interesting to see how a reasoning engine could then identify commonalities/ disputes from individuals' contributions.
  2. From the interface point of view, provide a Back button (if you press something by mistake). From the argumentation point of view, it was not clear to me if when I was asked to list 'consequences' I needed to include only consequences which had the same orientation of the proposal, or whether I could also include "adverse side effects".
  3. The sharp distinction between goals and values is arbitrary; sometimes a chain of subgoals is better (but I may be biased by my own research). Better overview is needed at any point in the interaction, e.g. with argument visualisation techniques. Sometimes degrees instead of binary yes-no answers are desirable (e.g. laptops sometimes or somewhat distract the audience).
  4. I did not find the fact that I could not enter free-text response to be too restricting. However, what I did find made it difficult to understand the question sometimes is that the questions have a very strict Practical reasoning format, i.e. "do you think *action* would improve *value*". I think some of the question would be easier to understand if they were phrased more naturally.

5. At times I felt like I needed to know what Parmenides was going to ask me *next* in order to answer the question at hand. It was a little unclear also when, and to what extent, the things I added in were going to be available subsequently (i.e. whether they'd be appearing in drop down boxes later on).

6. Either provide a "Back" button, or warn that it won't be available.

7. The first page, which asks whether the user agrees with everything in the position statement doesn't make it clear whether one is agreeing with the elements of the position statement or the conclusion that the proposed policy is best. There may be alternative, better policies, even if all of the statements in the position are true.

- **Do you have any suggestions or comments related to online opinion gathering systems in general?**

1. Opinion gathering systems where responses are predefined (like most of the opinion polls, not necessarily on-line) can more easily be manipulated to obtain the results one wants from the audience. One would expect the more advanced, AI based tools, could at least try to avoid this, if their main aim is to increase the level of public debate.

9.5.1.3 Phase 2 - Quality and Quantity of Results

The second phase of the evaluation involved the solicitation of opinions at a software demonstration held during the COMMA 2010 conference in September 2010. During the demonstration, those who attended were invited to interact with the system in order to submit their opinions on the particular topic of debate and provide feedback using the web-based questionnaire. In contrast to the other evaluations, the participants here could interact with the software demonstrator, who had expert knowledge of the system, in order to answer any questions that they had about Parmenides or to provide any necessary guidance.

A total of nine responses were received. Before interacting with the system, participants were asked whether they had participated in phase one of the evaluation. To prevent duplicated responses, only those who had not participated in the first phase were invited to use the system during the second phase of the evaluation.

The full list of respondents is illustrated in Figure 9.7.

From the responses, we see that none of the users agreed with the position presented to them. Of the nine responses, seven went on to submit an alternative position after critiquing the initial position presented. Seven users also submitted opinions on the system using the questionnaire. The high level of response to all aspects of the system

Result Analysis

ID	Name	IP	Agree?	Critique?	OwnOpinion?	Questionnaire?
9	[illegible]	[illegible].81.197	No	Yes	No	Yes
10	[illegible]	[illegible].80.143	No	Yes	Yes	No
11	[illegible]	[illegible].80.143	No	Yes	No	Yes
12	[illegible]	[illegible].147.10		Yes	No	No
5	[illegible]	[illegible].137.251	No	Yes	Yes	No
4	[illegible]	[illegible].137.251	No	Yes	Yes	Yes
1	[illegible]	[illegible].137.251	No	Yes	Yes	Yes
2	[illegible]	[illegible].137.251	No	Yes	Yes	Yes
3	[illegible]	[illegible].137.251	No	Yes	Yes	Yes
0	[illegible]	[illegible].137.251	No	Yes	Yes	Yes

Figure 9.7: Evaluation II, Phase II - Webpage displaying summary information regarding submissions

could be due to the encouragement and support available in the form of the expert system administrator. I discuss this further in Section 9.6.

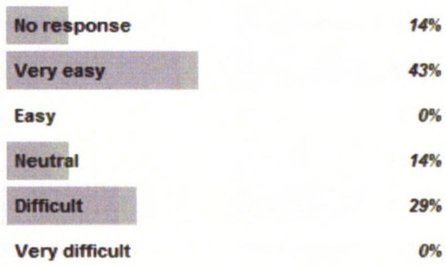
The complete set of responses to the debate are detailed in Appendix A. In the next section I present the results of the questionnaire before concluding with an overall analysis of the results of the second evaluation.

9.5.1.4 Phase 2 - Results of Questionnaire

A relatively large proportion of respondents provided a response to the questionnaire during phase two of the second evaluation. This could be attributed to a number of factors, including the expertise of the respondents in the domain in which Parmenides is based (thus, participants are likely to have comments related to the system) as well as the guidance and encouragement of the Parmenides expert administrator. I acknowledge that the presence of an administrator (and hence, to some degree, lack of anonymity) could lead some users in to giving different responses than if they were to submit the questionnaire with absolute anonymity.

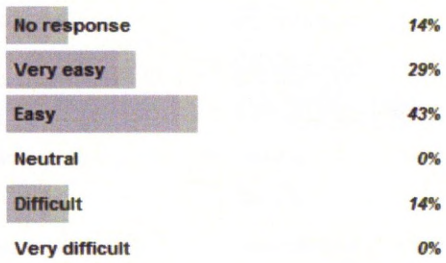
The results of the questionnaire were as follows:

1. How easy did you find it to understand the difference between the elements of the proposal (e.g. circumstances, consequences, social values)?



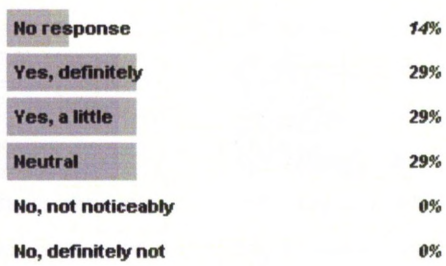
(n=7)

2. How easy did you find it to express exactly why you disagree with the proposal?



(n=7)

3. Did being able to see the constituent parts of the proposal make it easier to focus on your specific reasons for disagreement?



(n=7)

4. Did the fact that you couldn't enter free-text responses restrict your ability to respond appropriately?

No response	14%
Yes, definitely	0%
Yes, a little	29%
Neutral	0%
No, not noticeably	43%
No, definitely not	14%

(n=7)

5. Did you submit an alternative position after critiquing the proposal presented?

No response	14%
Yes	57%
No	29%

(n=7)

If Yes to Q5:

(a) Did you feel you were able to express your opinion sufficiently?

No response	0%
Yes, definitely	75%
Yes, a little	0%
Neutral	25%
No, not noticeably	0%
No, definitely not	0%

(n=4)

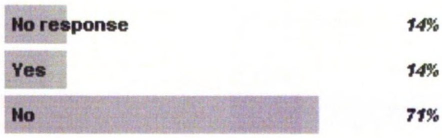
If No to Q5:

(a) Please tell us why you didn't submit an alternative position:

No response	0%
Did not have an alternative position in mind	100%
Did not have time	0%
Did not see the option	0%
Did not understand how to use it	0%
Other	0%

(n=2)

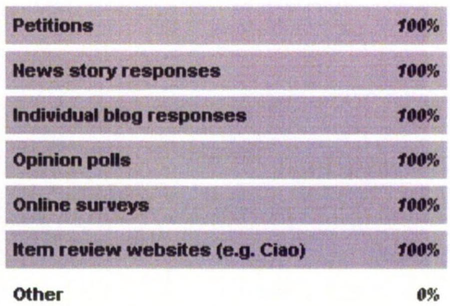
6. Have you previously used websites that gather public opinion?



(n=7)

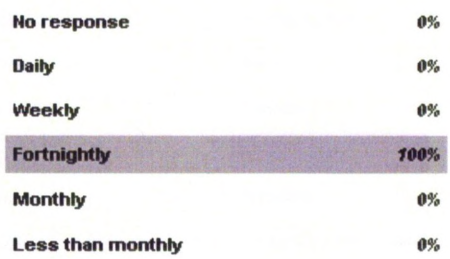
If Yes to Q6:

(a) Which kinds of website have you used?



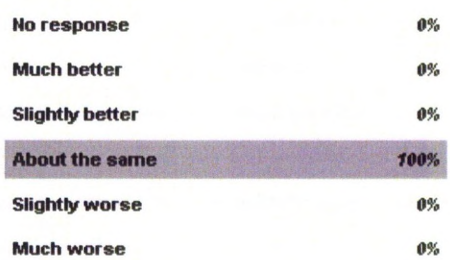
(n=1)

(b) How often (on average) do you use such websites?



(n=1)

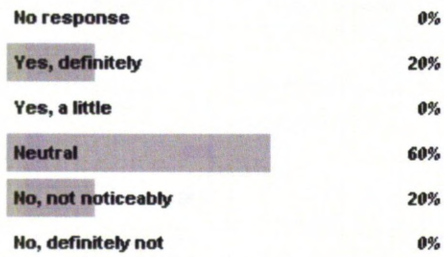
(c) How does Parmenides compare to these other websites, overall?



(n=1)

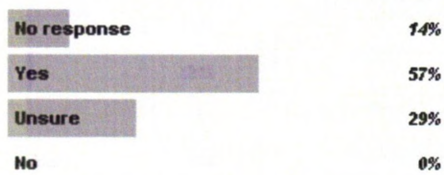
If No to Q6:

(a) Has the Parmenides website encouraged you to share your opinions more often?



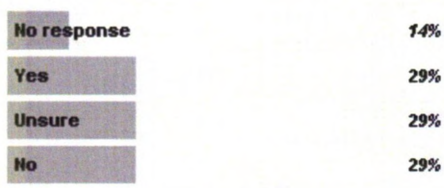
(n=5)

7. Would you use Parmenides again?



(n=7)

8. Would you use Parmenides regularly to participate in opinion polls that are relevant to your life?



(n=7)

A small selection of in-depth and useful comments were received to the free-text elements of the questionnaire during this evaluation, and these are listed below:

- **Do you have any other suggestions or comments related to Parmenides?**

  1. The only particular improvement that came to mind was to do with having to keep the information in mind across the different web pages. For example when it asks you about the goals, I had to think for a minute about which bit of the scheme you meant.
  2. In 'Our Position, I think it would be handier and easier if the different reasons for the proposal would be presented as different reasons rather than as 1 huge argument. For example: Argument 1: We want to allow the

> speaker to concentrate. However, laptops distract. Banning laptops results in the speaker to be better able to concentrate. Argument 2: We want to reduce distraction for others, however, laptop distract. Banning laptops would result in others to better able to concentrate. In other parts, some statements are too blunt. For example, in 'Circumstances' you must say whether 'those who use laptops are not concentrating on the presentation' is true or false. However, I think this is typically the case, but not always. Some who use laptops do know very well what the presentation is about.

9.5.1.5 Analysis of Results

In contrast to the first evaluation, described earlier in this chapter, the second evaluation was a two-phase process which was targeted towards researchers working within the field of argumentation. This choice of respondents was intended to gauge the opinions of such an audience towards the structure employed by the system, with the intention of receiving useful feedback from these users. Indeed, a large number of comprehensive free-text responses were submitted by respondents, which provided a useful insight and highlighted areas in which the system could be improved. Issues highlighted by users, and potential ways in which they could be addressed are discussed in Section 9.5.1.6.

During the first phase of the evaluation, respondents were targeted by email in a similar manner to the first evaluation. Despite this similar method of engagement, the response rate was significantly lower, with only 50% of those who were targeted going on to use the system. As the respondents to the second evaluation were less well-known to me than the colleagues who were invited to participate in the first evaluation, it is possible that this introduced some apathy in responding to (or even carefully reading) the email. It is difficult to speculate on how this may reflect on the kind of response that the system would receive if it were to be used in an e-Democracy setting. If the system were to be used to influence real policy decision, and was marketed to a wide audience then the response rate could be significantly higher than a closed-group evaluation.

Of the users who took part in the first phase of the evaluation, only two agreed with the initial position presented by the argument, and hence were not given the opportunity to provide a critique (or respond to the questionnaire). In contrast to the first evaluation, analysis of the responses indicates that users who disagreed with the initial position did not attempt to re-enter the system. Of the users who submitted a critique of the initial position, 4 out of 12 (33%) went on to submit a critique. This is considerably more than the 13% that went on to submit an alternative position during the first evaluation. Of the users who did not provide an alternative position (but did respond to the questionnaire), 80% said that they did not have an alternative position in mind. During both the first and second evaluation, one of the main reasons for users not providing an alternative position was that they did not have one in mind. I consider future enhancements to the system, which could potentially increase the volume of alternative positions provided by users, in Section 9.6.

During the second phase of the second evaluation, none of the users agreed with the position presented and hence all users provided a critique of the position. Of these nine users, seven (78%) provided an alternative position. This response rate is far higher than any of the previous evaluation conducted, and could be attributed to the presence of a human Parmenides expert who was able to provide the users with support in formulating an alternative position. Although Parmenides is intended to be a system that can be used without the presence of a human facilitator, the results of this evaluation seems to show that users are more responsive when such a facilitator is present.

Digging deeper into the responses received to both phases of the second evaluation, I consider the results of the questionnaire. Predictably, the spread of results for the first question ("How easy did you find it to understand the difference between the elements of the proposal") was less for the second evaluation than the first, with most users believing that it was either "Very easy" or "Easy". This is not surprising, as one would expect researchers within argumentation to be more familiar with software systems to support the argumentation process.

When asked how easy they found it to express exactly why they disagreed with the initial position, most users responded that it was either "Easy" or "Neutral" (combined total of 72% during the first phase, and 60% during the second). However, there was a notable 30% of users during the first phase who stated that this was "difficult". Similar results were yielded for the question of whether being able to see the constituent parts of the proposal made it easier to focus on the specific reasons for disagreement, with all users of the second phase stating that it was either easy or neutral. Meanwhile, 30% of users during the first phase described it as difficult to express their disagreement.

In response to the fourth question about whether the lack of free-text responses restricted their ability to respond appropriately, most respondents to the first phase stated that it did to some degree (60%). 30% stated that it did not affect them at all. Again, the responses to this question were much more positive during the second phase, with 57% of users stating that it did not affect their ability to respond appropriately.

For users who submitted an alternative position, they are asked whether they felt that they were able to express their opinion sufficiently. Whereas the previous question relates to the expressivity of the first part of the website in which users critique the initial position, this question refers to the second part in which users can construct their own. Interestingly, responses to both of these questions were very positive for both phases of the evaluation, with all users stating that they were able to express their opinion sufficiently. This perhaps indicates that if the options available to users in the drop-down menus are chosen carefully, then users do not feel that this method of interaction seriously affects expressivity.

Of the respondents to the first phase of the evaluation 60% stated that they regularly used websites which gathering public opinion. When asked how Parmenides compares to these websites, 17% said that Parmenides was "slightly better", with 33% stating that it was "about the same" and 33% responding that Parmenides is "slightly worse". Although this seems slightly discouraging, some of those who had used other opinion gathering websites stated that they had used "News story responses", "Individual blog responses", and "Item review websites". These are all methods which allow users to enter free text, and hence are highly expressive, as discussed in Chapter 3. The key disadvantage of such methods, and one which Parmenides attempts to overcome, is that the free text is unstructured and hence analysis of the resulting data is difficult. Although Parmenides does overcome this limitation by providing structure (and some necessary limitations) to the data that users can submit, the current implementation of Parmenides does not allow users to access the analysis facilities and hence it is not neccessarily surprising that users do not see the advantages of Parmenides over more expressive methods.

When asked whether they would use Parmenides again, most users said that they would (50% for the first phase, and 57% for the second). Despite this, far less respondents felt that they would use Parmenides regularly to participate in opinion polls that were relevant to their lives; 10% said "Yes" and 40% "Unsure" for the first phase, with 29% and 29% respectively for the second. As discussed with relevance to the results of the first evaluation earlier in this chapter, it is conceivable that users would feel differently about this if the results of the debates presented in Parmenides were to be considered by the government with a view to influencing policy decisions.

Having discussed some of the most interesting statistics related to the opinions of respondents towards the Parmenides system, I now consider some of the free-text responses that users provided to the final two questions of the questionnaire. I respond to each comment in turn.

9.5.1.6 Response to Comments Raised by Participants

During Evaluation II, a significant volume of free-text responses were received by evaluation participants. These comments contained feedback and suggestions on the Parmenides system and many useful and interesting comments on how it could be developed. In this section, I consider each of the comments received and provide a response. Note that in some cases the comments submitted have been slightly re-worded or summarised in order to aid clarity. Additionally, some comments are not included because the topics raised have been answered in my response to another comment.

Comment 1: Why did you not explore the use of the value-based argumentation model to support on-line dialogue? The way the questionnaire is structured tends to force the user into a specific set of values and a specific argument for a proposition. Why not explore how a system can help someone form such a structure. So, you may provide a list of values that are relevant to the topic, ask which are promoted/demoted by a specific action, allow the user to explore the effects of certain actions, etc., and, through that, enable the user to form an argument that can be put into a debate. It would then be interesting to see how a reasoning engine could then identify commonalities/ disputes from individuals' contributions.

Response: This user questions the interactivity of the system, and suggests that rather than presenting an argument to the user for him to critique, the system could allow the user to create the argument himself. This is somewhat similar to the facilities already offered by the alternative position construction element of the Parmenides system, with additional functionality of a "reasoning engine" which would identify points of agreement and conflict in the positions submitted by users. This is an extension to the system which would lead on quite naturally from the functionality currently offered by the system, and hence could be considered for future work. I did not explore this as part of my thesis as it does not necessarily address the research issue which I set out to tackle, which concentrates on the ability for the government to gather public opinion on a particular policy proposal. This is achieved in Parmenides by the use of a particular formal structure of argument which permits critical evaluation of the particular position under consideration. The use of values within Parmenides is intended to provide justification for a particular argument, which the user can disagree with and go on to provide their own set of values and justification for action.

Comment 2: From the interface point of view, provide a Back button (if you press something by mistake). From the argumentation point of view, it was not clear to me if when I was asked to list 'consequences' I needed to include only consequences which had the same orientation of the proposal, or whether I could also include "adverse side effects".

Response: The first point noted by this respondent was also noted by other respondents. Although the browser "Back" button should operate in most cases, I acknowledge that the provision of a separate "Back" button alongside the "Next" button at the bottom of each page would be a useful addition. Regarding the second comment, all consequences listed within the system should be good consequences as they promote social values, which are always positive. In order to resolve this, "Consequences" could be consistently renamed to "Goals" throughout the interface. The original argumentation scheme used within Parmenides, which is introduced and discussed in Chapter 4, differentiated between the notion of a "Consequence" and that of a "Goal" (goals being a desirable subset of the consequences). Consequences and goals were deliberately *not* differentiated in the implementation of the argumentation schemes within

Parmenides, in order to prevent confusion and to allow users to interact more easily within the system. Within some parts of the interface the two terms may have been used interchangeably, and this should be corrected in future versions of the system.

Comment 3: The sharp distinction between goals and values is arbitrary; sometimes a chain of subgoals is better (but I may be biased by my own research). Better overview is needed at any point in the interaction, e.g. with argument visualisation techniques. Sometimes degrees instead of binary yes-no answers are desirable (e.g. laptops sometimes or somewhat distract the audience).

Response: My response to the first point raised here is that my view of argument using values, which utilises a particular scheme for practical reasoning which is based on the promotion of values by carrying out actions, places a subtle but clear distinction between goals and values. Values represent a very general desirable social interest, with no consideration of what will be done to achieve this. On the other hand, a goal should detail the exact state that is to be realised, the reasons for the desirability of which are provided by the value. For example, *Saving Lives* is a value which has been used in the running example presented throughout this thesis. This qualifies as a value because of its generality; there are numerous states that one could think of to realise this value, and no particular one is given in the value statement itself. It is the goal (for example "Reducing the road death toll"), that details the exact state which promotes the value. The software system that I have implemented makes use of the notion of value-based argumentation, which is a field that is well documented in the computational argumentation literature.

The second point raised by this respondent is that a better overview of the debate could be useful to the respondent. Although this could be interesting and useful to respondents, care would need to be taken in order to avoid adding unnecessary confusion to the interface; those who are simply wishing to voice their opinion on the topic of debate may become unnecessarily confused by the inclusion of additional argument representation features. This would require considerable further research and evaluation, and hence is not considered in detail within this thesis.

The final suggestion from this respondent is that "degrees" of agreement would be desirable instead of "Yes" and "No" answers. Although this might be useful for users, it would be difficult to implement given the underlying structure of argument implemented within Parmenides. The arguments within Parmenides are based on argumentation schemes for practical reasoning, which can be challenged using critical questions. These critical questions can either be posed or not posed, which is achieved by answering "Yes" or "No" through the Parmenides critique webpages. Forcing the user to commit to agreement or disagreement allows for definite conclusions to be provided to those who analyse the results of the debate using Argumentation Frameworks. Allowing users to respond instead using degrees of confidence (for example: definitely, maybe, neutral, maybe not, definitely not) would introduce difficulties in the application of Walton's argumentation scheme model to the system, and would require modifications to the analysis features. The aim of this thesis was to implement a system for opinion gathering based on argumentation schemes for practical reasoning, with associated analysis features. Future research could focus on the modification of arguments to permit these differing levels of certainty, but this does not fall within the scope of the work presented in my thesis.

Comment 4: I did not find the fact that I could not enter free-text response to be too restricting. However, what I did find made it difficult to understand the question sometimes is that the questions have a very strict Practical reasoning format, i.e. "do you think *action* would improve *value*". I think some of the question would be easier to understand if they were phrased more naturally.

Response: It is reassuring to see that this user did not find the lack of free-text responses to be too restrictive, as this could be considered as one of the main limitations of a system such as Parmenides. The issue of the phrasing of questions within Parmenides is less related to their "practical reasoning format" as it is to the generation of the questions using the automated Debate Creator tool. In developing this tool, sentence templates had to be phrased carefully to ensure that they would make sense given any instantiation of those sentences with elements related to any debate. Although the result of this is sentences that may sometimes not read as they would in a natural language conversation, this is a necessary trade-off of using computer-aided debate creation.

Comment 5: At times I felt like I needed to know what Parmenides was going to ask me *next* in order to answer the question at hand. It was a little unclear also when, and to what extent, the things I added in were going to be available subsequently (i.e. whether they'd be appearing in drop down boxes later on)

Response: It is unclear from this response exactly why the user felt that he needed to know what the system was going to ask next. Indeed, the questions posed to users during the critique stage of the system are intended to be considered as standalone entities, which should be answered without consideration to their context in the debate as a whole. This allows for the individual elements of the debate to be questioned in isolation, thus allowing the creators of the debate to determine exactly which part of their position is most agreed and disagreed with. For example, when asked whether a particular value is worth promoting, this should be answered as a general standalone question, rather than whether the value is worth promoting within the context of the debate.

Comment 6: The first page, which asks whether the user agrees with everything in the position statement doesn't make it clear whether one is agreeing with the elements of the position statement or the conclusion that the proposed policy is best. There may be alternative, better policies, even if all of the statements in the position are true.

Response: The statement on the first page was changed from "Do you agree with the above position?" to "Do you agree with *all* of the above position?" as a result of some comments that were made by some early users of the system. The user should state that he agrees with the position statement if he agrees with all of the written statements presented. However, in the current state of the system, respondents are not given the opportunity to present an alternative position if they state agreement with the initial position presented. This is perhaps incorrect, as agreeing with the initial position does not mean that the user feels that this is necessarily the best proposal. Future enhancements to the system could include asking the user not only whether he agrees with the initial position as presented, but also whether he feels that another, better, policy (or policy justification) could be proposed. This would allow users to choose at the beginning of their interaction with the system whether they wish to submit a critique, an alternative position, or both.

Comment 7: In 'Our Position', I think it would be handier and easier if the different reasons for the proposal would be presented as different reasons rather than as 1 huge argument.

Response: If it transpired that many users shared this view, it would not be too difficult to implement this (as debates are entered this way in the debate creator, and are also analysed in this way). The overall benefit of separating the arguments in their presentation to the average layperson is questionable, as it could lead to confusion over there being multiple arguments all of which promote the carrying out of the same action for different reasons (i.e. the different values promoted). If a future large-scale evaluation was carried out with laypersons, the two different methods of presenting the argument could be presented in order to determine which one users prefer.

9.6 Discussion

Firstly, it is worth noting that this evaluation considers only part of the Parmenides system - the public interface. At this point it is prudent to re-iterate the points made in Chapter 5, specifically that the system is designed to reach a trade-off between how expressive respondents can be and the ability of the results to be computationally anal-

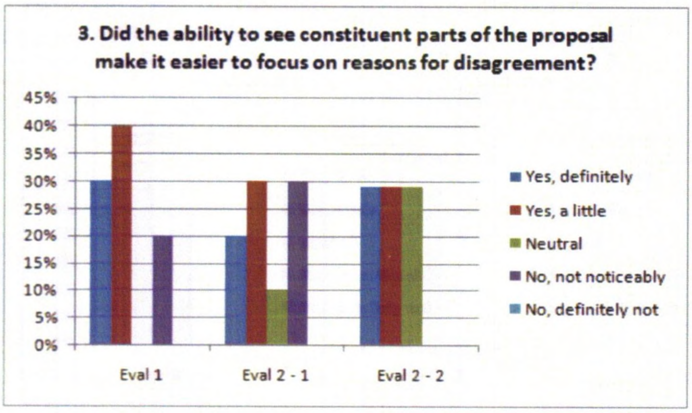


Figure 9.8: Parmenides Evaluation Questionnaire - Graph (1)

ysed. Therefore, it is not particularly surprising or disheartening to discover that many of the evaluation participants did not see the full advantage of tools such as Parmenides (as the data analysis facilities are only available to administrators). Despite this, when asked whether the ability to see the constituent elements of the debate made it easier to focus on their exact reasons for disagreement, many users felt that it did (see Figure 9.8). This shows that, although one of the main arguments for applying structure to the system is to permit computational analysis of the data collected, it is also perhaps the case that users also find this structure useful in order to clarify their own points of agreement and disagreement.

It is promising that very few users of the system stated that they would not use Parmenides again (10% during the first evaluation, 0% in both phases of the second - see Figure 9.9), although a bigger proportion stated that they would not use Parmenides regularly to participate in opinion polls. It is possible that, as mentioned previously, users would be more inclined to use the system if it contained debates that were to be analysed by the government in order to make decisions over policy proposals. Other incentives could also include making some degree of data analysis available to users, so that they could see how their opinion fits in with those submitted by others.

A trend that was evident across all of the evaluations is that many users who provide a critique of the initial position do not go on to provide an alternative position, with most respondents to the questionnaires stating that they did not have an alternative position in mind. In the previous section, I suggested that this could be remedied by modifications to the user interface. I identified one particular modification to the system which may go some way to resolving this issue in Section 9.5.1.6. I suggested that, rather than simply asking the user whether he agrees with the initial position presented at the start of his interaction with the system, he could also asked whether he believes

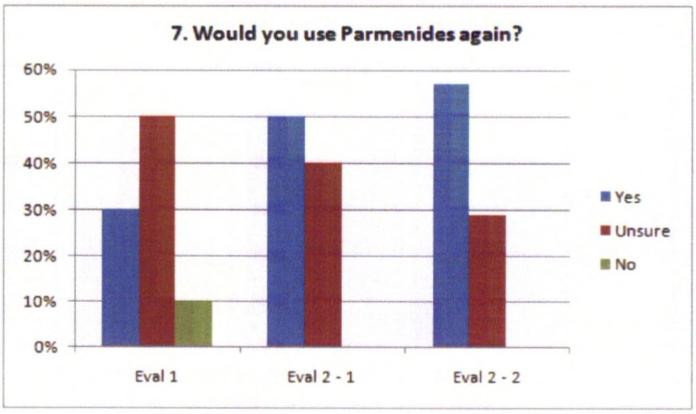


Figure 9.9: Parmenides Evaluation Questionnaire - Graph (2)

that there is another, better policy (or policy justification) which could be considered by the government. This is in contrast to the current set up of the webpages which does not mention alternative positions until *after* the user has provided their critique.

One interesting observation amongst the collected data is that it was participants of Phase 2 of the second evaluation who used the features of the system most extensively. Participants of this evaluation could draw upon an expert system administrator, who was present throughout their interaction with the system, if they required any help or advice on using the system. The results of this evaluation indicated that almost all participants submitted an alternative position, in contrast to Evaluation I and Phase 1 of Evaluation II, in which less than half of participants took the opportunity. This could be related to the system administrator being on hand to offer guidance on, for example, what constitutes an alternative position and how the process works.

Future evaluations could investigate this further by conducting more trials during which an administrator was present, and comparing the results to those conducted without an administrator. If the results showed that interaction was improved when an administrator was present (administrators are often called "facilitators" in this context), then this could indicate that either the documentation and support features available on the website are insufficient, or perhaps that participants simply prefer the presence of a facilitator. In any system for e-Democracy, which is intended to be used by citizens in their own homes, the permanent use of a facilitator is obviously not possible. An alternative avenue of research that could be pursued is the use of Parmenides in focus groups, which are small but representative groups of people who participate in opinion polls. If Parmenides was to be used for these small focus groups rather than made available for public use, then the use of a facilitator would be possible. Alternatively, a trainer could be present during users' initial interactions with the tool, thus allowing respondents to develop confidence in using the tool before using it independently later. The Parmenides tool itself is not specific to one particular implementation environment; it could be implemented for wide public access or restricted for use by small groups with little or no changes to the way in which the software is designed and programmed.

The evaluations that I carried out allowed users to have a "one off" interaction with the system; the respondents had not previously been exposed to Parmenides, and were not exposed to it again after their initial interaction. It is possible that as users become more familiar with the way in which Parmenides operates, that they would develop more confidence in using the tool and hence be able to interact with it more easily and efficiently.

The evaluations that I carried out as part of my research, and described in this chapter of my thesis, provide an insight into the opinions of those who used the system. It highlighted the strong points of the system, as well as many of the parts of the system that could be improved. Interestingly, some of the aspects of the system which were previously thought to be weak points (for example, the restrictions on how expressive users can be) seemed to be of little concern to participants of the evaluations.

Future evaluations could be done using different target audiences, different audience sizes, and different topics of debate in order to gain more feedback on the system. For example, the two evaluations described in this chapter concentrated on the presentation of the system to PhD students working in a number of different Computer Science base disciplines and researchers working within argumentation. Future evaluations could try to appeal to audiences from a wider range of backgrounds across a wider age range, in order to simulate the target audience of the system if it was to be implemented for public use. Other factors could also be tested; for example, further evaluations in contained environments with the presence of a facilitator in order to determine whether the quality of interaction is increased. Evaluations could also concentrate on other aspects of the system. For example, parties who currently use opinion collecting mechanisms could trial a debate within the Parmenides system, and use the analysis facilities to analyse the responses. Useful feedback could be gained about how the Parmenides method of data analysis compares to others that are currently used to analyse public opinion (e.g. simple statistical opinion polling).

9.6.1 Comparison with Evaluations of Other Tools

In Chapters 2 and 3 of this thesis, I conducted a survey of existing tools which support the process of argumentation, both within the domain of e-Democracy and a range of other domains. As these tools are intended to be used to support the process of argument among their user base, many of them have been subject to evaluations similar to the Parmenides evaluation described here, in order to prove their effectiveness. In this section, I briefly investigate the literature describing such evaluations.

9.6.1.1 Aracuaria - Teaching Case Study

In [133], a small study of the Araucaria diagramming tool (introduced in Section 2.2.5.1) is described. During the study, a group of students enrolled on an argumentation course were asked to use the tool to construct argument diagrams. This user group is somewhat different to the user group chosen for the Parmenides evaluation, as they are very knowledgeable on the subject of argumentation and hence would be less likely to experience any ease of use issues.

Once the student had finished creating argument diagrams using Araucaria, he was asked to fill in a short questionnaire to provide feedback on the system. As the system is implemented in a different subject area than Parmenides (teaching, as opposed to e-Democracy), with different purposes (to support the creation of diagrams, rather than to collect and analyse opinion), some of the questions posed to users are largely incomparable to the Parmenides evaluation.

One of the questions asked of participants was regarding the "Necessity of practice/lab sessions on learning to use Araucaria outside the regular classes". 54% responded that the necessity was "High", with a further 16% considering it "Medium". Additionally, users were asked about the "Necessity of extra help learning Araucaria", to which 22% users responded "High" and 34% "Medium". This illustrates the requirement for training before using tools which employ structures of argument or require users to create formal structures of argument.

Another interesting response was that obtained when users were asked "Possible application of Araucaria as a device helpful in learning better writing and argumentation skills". Only 21% of users stated that this was "High", and a similar low number was obtained during the Parmenides evaluation when users were asked whether they would use Parmenides regularly to participate in opinion polls. This could indicate that users are initially reluctant to accept new tools to assist in the process of argumentation, perhaps due to lack of familiarity. It would be interesting to determine whether the response to these questions (both in the case of Araucaria and Parmenides) becomes more positive once users have interacted with the system a number of times.

9.6.1.2 CoPe_it! - Use in Communities of Practice

An evaluation of the *CoPe_it!* tool, presented in Section 2.2.5.9 as a tool to support collaborative argumentation in communities of practice, is described in [75]. A total of 67 users interacted with the tool and then, in a similar manner to which the Parmenides evaluation was carried out, completed a questionnaire in order to ascertain their opinions on its usefulness. The main findings of the evaluation are summarised in [75] as follows:

- 74% of users found the tool easy to learn

- 71% of users found the tool easy to use
- 66% of users said the tool was "worth the effort"
- 37% of users said that the tool would be their first choice for supporting future collaboration
- 83% of users responded that it was easy to understand the tool's features
- 52% of users could easily understand the contents of a "workspace" within the system

The results obtained during the evaluation of *CoPe_it!* bear some interesting resemblance to the results that I obtained during the evaluation of Parmenides. For example, despite the fact that the majority of users found the tool easy to learn and use, and responded that it was "worth the effort", only 37% of users stated that they would use the tool as their first preference in future interactions.

A similar trend can be seen in the data obtained during the Parmenides evaluation, as illustrated in Figure 9.10. For example, a total of 50% of users stated that being able to see the constituent parts of the argument made it easier to focus on their reasons for disagreement, yet only 10% of users said that they would like to use Parmenides to regularly participate in polls relevant to their lives.

9.6.1.3 QuestMap - Industrial Case Study

In contrast to the other evaluations and case studies described in this section, which describe short term usage of the respective tools, the case study of QuestMap presented in [40] describes a prolonged use of the system within an industrial setting. Specifically, the QuestMap system was used at Southern California Edison by up to 50 users in order to "capture operational decisions and the rationale behind them".

Unlike the Parmenides evaluations described in this chapter, the use of QuestMap described in [40] was not intended as an evaluation of the system. Rather, the system was sold for use by Southern California Edison. For this reason, there is no quantitative data to back up the findings of the case study (for example, questionnaire results), but the case study does present some interesting reflections on how the system was used within the company and the issues encountered during its use.

One particularly interesting factor is that, although the QuestMap system is based upon the IBIS argumentation method, none of the users of the system had any previous exposure to this structure and hence could be considered as laypersons. This turned out to be a considerable issue in the use of the system - users needed to be sent on a 3-day course in how to use the IBIS structure of the system before they were able to interact with it. Despite these training sessions, it transpired that even some long-term users of the system still did not fully understand how to use some features of the system

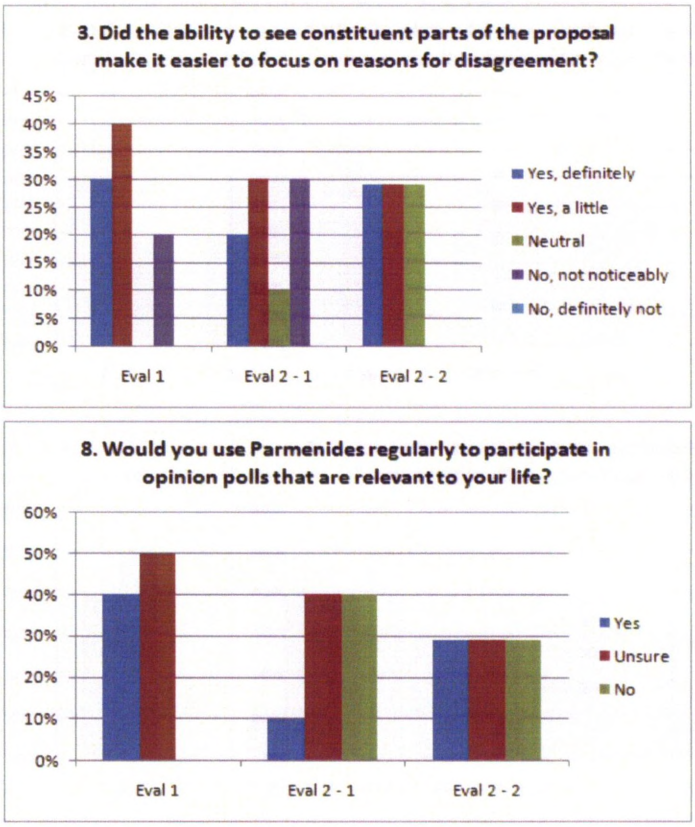


Figure 9.10: Parmenides Evaluation Questionnaire - Graph (3)

(the "hypertext facilities" is specifically mentioned in the case study). This provides a concrete example of exactly why the use of structured formalisms in systems that are to be used in casual interaction by laypersons within e-Democracy must be carefully considered.

9.6.1.4 HERMES

In [74], the results of a number of evaluations carried out on the HERMES system are described. HERMES, described in Section 3.3.2.3, is a system designed to support the process of collaborative decision-making. The evaluations of HERMES described in the literature are wide-ranging, and include evaluation within research labs, within a university department, and in the domain of medicine. An average of 9 users interacted with the system during each of the evaluation phases, each user having access to an individual computer in a different room than other participants.

The authors describe a training process of approximately one hour that was required to familiarise users with the system. Again, within the context of e-Democracy this would be an excessive amount of time for users to spend learning how to use a system that they interact with on a casual basis. A human moderator was also made available to supervise users interaction with the system and to "assist the users whenever needed".

To evaluate users opinions on the system, a questionnaire was distributed to 61 of the evaluation participants, of which 50 responses were received. In a similar manner to the Parmenides questionnaire, most questions were answered by choosing one of five possible responses (ranging from Strongly agree to Strongly disagree). Although many users found the HERMES system easy to use (80%-90%), only around 50% of users said that they intended to use the system again. This bears an interesting resemblance to the trend noted for both the Parmenides evaluations carried out as part of this thesis, and the *CoPe_it!* evaluation described earlier in this section. This similarity perhaps indicates that users are initially apprehensive about using new tools to carry out familiar tasks. It would be interesting to see whether, if users were invited to use the system on further occasions, whether they would become less apprehensive about using it on a regular basis.

9.7 Summary

In this section, I have provided an overview of two separate evaluations that were carried out on the Parmenides system. Although both were conducted with relative small audiences, the feedback obtained gives an interesting insight into how the system is perceived by users and possible improvements that could go some way to further enhancing the system.

The first evaluation was targeted towards PhD students, across a range of disciplines within Computer Science. Many of these can be considered as effective laypersons, as the majority of those targeted were not working within the research area of argumentation. The second evaluation was intentionally targeted towards those who are working within argumentation. The participants chosen were all academics from a variety of institutions around the world, and a useful range of survey responses were received which highlighted both the positive aspects of the system and aspects which would benefit from further development.

I concluded the chapter with some comments on evaluations that have been carried out on other tools which support the process of argumentation, and identified some of the interesting trends between the data obtained during the evaluations of these tools and the data obtained during the Parmenides evaluation.

Chapter 10

Conclusions and Future Directions

10.1 Overview

In this section, I discuss the contributions of my thesis and consider how far my findings have addressed the research question set out in Chapter 1. I also examine how the research I have presented could be extended and developed in future work.

10.2 Summary of Contributions

The aim of this thesis, as defined in the research question set out in Chapter 1, is as follows:

> *How can democratic decision making be supported and enhanced by technologies that make use of computational models of argument?*

Throughout this thesis I have developed a set of software tools, named Parmenides, which address this question and the more specific goals articulated in Section 1.3. The grounding on which my software tool is based is a set of existing well-founded theories of argument, which I have developed and extended in order to facilitate structured, expressive exchange of argument between government and citizen. The result is a software toolset which aims to be both easy to use and provide useful data analysis features.

In Chapters 2 and 3, I investigated a wide range of existing software tools to support argumentation. Whilst Chapter 2 presented a general investigation into argumentation support tools, Chapter 3 specifically concentrated on tools which support political democratic discourse through the process of argumentation. I identified one of the main distinctions of such tools; namely, those which are based upon formal models of argument and those which support more informal argument. I then discussed the shortfalls inherent to each of these categories of tool: Those which are based on formal argument are typically difficult for laypersons to use; but tools which are based on informal argument do not allow for easy and effective computational analysis of the resulting data.

Chapter 4 began my investigation into bridging the gap identified between ease of use and the provision of useful analysis facilities. I introduced and discussed the background of practical reasoning, an area of research which concentrates on reasoning over choices of action to be taken, before considering how practical reasoning can be implemented in computational tools.

I then went on to introduce an early basic prototype of the Parmenides system which was developed by Atkinson *et al.* in [12] to demonstrate the implementation of their practical reasoning argumentation scheme in a tool for political opinion gathering. Chapter 5 described my development of this prototype to include a suite of analysis tools for debate administrators, which is based on formal theories of argument visualisation and analysis. I defined how critiques of arguments instantiated using Atkinson's practical reasoning scheme could be represented in terms of Dung's Argumentation Frameworks and Bench-Capon's Value-based Argumentation Frameworks.

In the context of the tool that I have created, the argumentation life cycle consists of a number of stages, including the creation of a topic of debate; interaction with a debate by the public; and the analysis of the resulting data in order to determine conclusions. The webpages and back-end database that I created fulfill the interaction stage of this life cycle, and the analysis tools described above permit analysis of the data stored in the database. To assist with the first stage, I presented a system which assists with the automated creation of new debates. The tool represented a significant development as it allowed democratic debates to be easily created and added into the system, whilst adhering to the underlying structure of debates.

Although the system that I developed does force certain constraints on the user in order to ensure that contributions to the system are structured in a way that can be analysed, I believe that it meets the criteria defined in the first chapter of this thesis. Those criteria were that the system should "provide computational analysis of the data collected", that it must be "easy for a layperson to understand and use" and that it should "provide respondents and governments with the ability to be as expressive as possible". The evaluations of the system carried out in the previous chapter indicated that, overall, users did not find the system difficult to understand and use. Users also seemed to be fairly content with being forced to choose their responses from drop-down boxes and "Yes or No" responses to questions and, overall, did not find this to have a large impact on how expressive they could be.

In Chapter 6, I investigated how the theories underlying the Parmenides structure of debate (i.e. argumentation schemes) could be extended in order to allow interaction between different debates. This is a feature of every day conversation - facts are challenged or supported by providing another argument. The research described in this chapter was intended to fulfill another of the criteria defined earlier in my thesis: *"To consider how the structured representation of different arguments can interact, to support and challenge each other [...], in order to allow for increased expressivity in structured argument"*. I explored the interaction between arguments by way of a number of examples, which I then generalised in order to define a provisional theory of the interaction that can take place between arguments instantiated using different schemes. Chapter 7 built upon this work by providing a software implementation of these theories within the Parmenides system. This served two purposes: Firstly, it enhanced the expressivity available within the system by allowing debate creators to provide additional arguments to support the facts presented in their main argument. Secondly, it served as an initial software implementation of the theories, to investigate their effectiveness within a specific domain. I presented a significant extension both to the debate presentation and the debate analysis features of Parmenides in Chapter 7, which allowed the system to support the creation and in-depth analysis of argumentation scheme interactions.

Chapter 8 investigated mechanisms for automated decision making in agent-based systems, based on the use of argumentation schemes. The specific formalism considered was the Alternating Action-based Transition System, which allows for representation of, and reasoning over, the effects of actions in a multi-agent context. I briefly described some existing software implementations of the AATS and commented on how such a model could be used within Parmenides to assist debate creators in developing their positions. I considered the challenges that would be faced in developing a structure such as the AATS into a system capable of representing the scheme interactions defined in Chapter 6.

My thesis concluded with an evaluation of the system, which both demonstrated the strong points of the system and allowed me to identify areas which could be improved in future research. Overall, the evaluations conducted demonstrated that Parmenides provides a useful and novel contribution to the research area, which fulfills the criteria and provides insights into the use of computational argumentation in systems for e-Democracy.

10.3 Remaining Issues

In the previous section, I discussed the contributions made by this thesis and identified the elements of my research that answered the specific research aims defined near the start of the thesis. In Chapter 9, I considered the results of the evaluation, identified some of the limitations in my software system, and proposed how these may be investigated further and resolved. In this section, I extend this by considering both the Parmenides tool and the wider area of e-Democracy, and defining some of the issues that would need to be resolved in order to implement Parmenides or any other similar tool.

10.3.1 System Security and Privacy

Developing systems for e-Democracy that have a sufficient level of security and privacy is an issue that has received significant attention (e.g. [67, 174, 118]). Security and privacy are both identified in [53] as key features of any channel through which systems for e-Democracy are made available. With the popularity of online banking, the Internet certainly seems to have proved itself as a channel that is capable of providing a high level of both security and privacy.

There are a number of different aspects to the security of online tools, specifically those for e-Democracy, and I now discuss each in turn in the context of its application to the Parmenides system.

10.3.1.1 One Citizen, One Vote

This issue is obviously of major concern in the context of e-Voting, where citizens should not be able to manipulate the results of the vote by voting more than once. In [44], which considers electronic polling, Cranor and Cytron state that "A system is democratic if [...] it ensures that each eligible voter can vote only once". The same security concern also applies to systems for gathering public opinion, such as Parmenides, especially if the results are to be used to influence official policy. One can imagine how the results could be skewed if each person was allowed to vote more than once, especially on particularly contentious issues where respondents may feel motivated to do this in order to skew the results in favour of the decision that they favour.

For example, if the government were to create a debate based around reducing the benefits available to those who do not have employment ("We should reduce the benefits available to the unemployed"), then those who are receiving such benefits are likely to feel strongly about the topic at hand and may be tempted to submit multiple votes unless there are stringent security measures in place to prevent this.

The achievement of security in this respect perhaps depends on the final domain in which the software tool is implemented. For example, it may be achieved by assigning citizens specific ID numbers and passwords, which they use to access the online tool. However, this raises privacy issues: if the user is required to log into the system using an identity that is unique to him, then he may fear that the government could identify who made the particular vote. In the context of opinion gathering, this could dissuade citizens from participating in topics that may seem particularly controversial or, perhaps worse, providing responses that do not accurately reflect their personal stance.

10.3.1.2 Controlling Access to Submissions

This security issue concerns the access to the data that is submitted by citizens, and specifically access to this data by unauthorised parties. Unauthorised access to data could be gained in a number of ways; firstly, it could be gained by eavesdropping on unsecured Internet communications. This is a topic which has received much attention in recent years due to the advent of services such as Internet banking, which must utilise extremely secure channels of communication to prevent confidential data from being intercepted by unauthorised parties. The Secure Socket Layer (SSL) Internet protocol[1] provides a secure and widely used method of securing Internet communications.

One must also consider the security of data which has been collected from users and stored. Such storage is normally in the form of a computerised database. If the data stored is presented to users of the electronic tool, for example in the form of statistics regarding votes or opinions that have been submitted by other users, the designers must ensure that no information that could identify users of the system is made available. In 2002, the UK government made an online tool available through which citizens could submit tax returns. Later that year, the system was withdrawn because it emerged that users could see the tax returns of other citizens [148]. Such security issues highlight the need for tools to be robust and secure in order to build public confidence in submitting their personal information over the Internet.

Even in cases where stored information is not made available to the public, it is important to consider exactly who has access to which particular information within the government office. Obviously, the data stored within the database will need to be accessed at some point for analysis. It should be ensured that official bodies who have access to this data can not link individual submissions with any personal data, unless the user has specifically requested this linkage be made available.

10.3.1.3 Anonymity

The ability to remain anonymous when participating in democratic processes is important. For some democratic processes, this may not be possible; for example, when communicating with government officials, citizens may enter their email address or telephone number in order to get feedback from government representatives. The same also applies to tools for opinion gathering - citizens may feel that they wish to "make their voice heard" and hence wish to participate under their real name.

However, in cases where the information being solicited relates to a particularly controversial topic, users may wish to remain anonymous. As discussed in Section

[1] More information on the SSL protocol: http://info.ssl.com/article.aspx?id=10241

10.3.1.1, if citizens are forced to participate under their real identity, then this may affect the truthfulness of their answers. Therefore, the challenge here is to create a system that allows citizens to participate using their real identity, should they wish to do so, yet allow other users to feel confident that they can remain totally anonymous. At the same time, tool designers must ensure that this anonymity can not be exploited in order to manipulate the results of the system, as described in Section 10.3.1.1. Currently, the Parmenides system allows users to participate using either their real name or an alias of their choice. This means that those users who wish to participate using their real names are able to do so, whereas those who do not wish to be identifiable can still participate.

10.3.2 Usability

In this thesis, I have presented a system for opinion gathering in e-Democracy which attempts to provide structure to debates to aid their analysis in terms of structured models of argument, whilst remaining highly usable for laypersons. However, the main focus of the usability considerations of this thesis has been on the publically accessible parts of the system. Before making the system available for use by government debate creators, the usability of the system for debate administrators would need to be carefully evaluated.

For example, the Parmenides Debate Creator was introduced in Section 5.3.2. This interface leads the administrator of the debate through the process of entering the relevant details into the system, and then creates the relevant web and database files to allow the debate to be represented within Parmenides. Although this is undoubtedly far easier than forcing the administrator to create the website and database files himself, it still requires that the administrator has a reasonably in-depth knowledge of argumentation schemes in order to use the system. If the administrator were to enter details incorrectly, then the operation of the system would be impaired, and the analysis of the data resulting from the debate could be incorrect and misleading.

The same issues are also present with the argumentation scheme entry interface described in Section 7.3.1. Currently, the person entering a new argumentation scheme into the system must be highly trained in doing so. If the scheme is entered incorrectly, then debate creators may not be able to utilise it correctly in order to construct their positions.

Although the task of training a small group of debate administrators to use the system is not particularly expensive or time-consuming, it would be useful to make the system as foolproof as possible in order to reduce the possibility of mistakes. If this is to be achieved, then evaluations would need to be carried out in order to determine which parts of the debate creation system are most difficult to use and require further clarification. The evaluations carried out so far, described in Chapter 9, relate to the interaction of users (citizens) with the opinion gathering part of the website, whereas the evaluations alluded to here would concentrate on the debate creation aspect of Parmenides.

There are a number of steps that could be taken to address any usability problems identified by these evaluations - for example, the implementation of instructional videos to demonstrate the operation of the system, guided examples to show administrators how to correctly enter details, or the provision of additional "Help" material for specific parts of the system.

10.3.3 Encouraging Participation

Encouraging citizens to participate in both online and offline democratic processes has been a concern held by governments for many decades. In Chapter 2, I presented one particular piece of work by Bicking and Wimmer which prescribes the necessary conditions which must be met in order for any e-Democracy tool to be successful [28]. Amongst this list are included a number of factors which must be considered at the time that the system is implemented, for example "active moderation" and "frequent maintenance" of the system to ensure that it is up to date; and the choice of an "interesting and important" topic for the system.

Other factors must be considered at the time that the system is designed, and I feel that the Parmenides system presented in this thesis does fulfill these criteria. For example, Bicking and Wimmer state that the system should be usable and accessible to users. The fresh and modern interface, coupled with programming practices that ensure that the webpages can be used across a variety of web browsers, ensure that Parmenides achieves this aim.

The choice of an interesting and important topic of debate, as briefly discussed above, is perhaps one of the most important in order for a system such as Parmenides to be successful. These systems often rely on both word of mouth and media attention in order to attract users, and debates that do not capture the attention of these audiences are unlikely to be popular, regardless of the technical capabilities of the system itself. This is in contrast to decision support systems which are to be implemented in scenarios in which the user is effectively "forced" to interact with it, for example in business meetings. Here, the technical ability of the system may be sufficient to make it successful, rather than the hype created by users who interact with it.

10.4 Future Work

Here, I identify some of the possible future research directions for my work. I start by discussing extensions to the Parmenides software tool, before considering how the underlying theories could be expanded in order to enhance the representation and analysis of arguments within the system.

10.4.1 Parmenides

10.4.1.1 Profiling System

One of the tools that I developed for the Parmenides System throughout the course of my research is the Profiling System, which I described in some detail in Section 5.6. The Profiling System allows users to create an account on the Parmenides system, through which they can *optionally* submit a variety of personal information (age, gender, marital status, etc.) and participate in any of the debates currently active within the system.

The advantage to the user of this interface is that he can see the debates that he has participated in, and the critiques (and alternative positions) that he has provided in these debates. Possible future enhancements to the system could, for example, allow the user to view the critiques given by other users (see Section 10.4.1.2) or even interact with these critiques (see Section 10.4.1.3). The user need not have any privacy concerns, as he does not have to supply a real name and all of the personal information collected is strictly optional.

There are also advantages to the administrators of the system. Firstly, users who sign up to the profiler system may be more likely to return to the system and participate in future debates. The fact that the user can see which particular debates he has participated in might encourage him to participate in future debates. Additionally, as the profiler stores the users' email addresses, users could have the option of being sent email notifications to alert them of new debates becoming available in the system. Users could also have the opportunity to propose their own topic of debate, which would then be considered by the system administrator and added to the system if appropriate. The second advantage of the profiler system is that there is potential for a large amount of demographic profiling to be done on the results of debates.

It is this demographic profiling potential that I now turn to explore in more detail. The initial prototype that I have developed possesses the capability for administrators to define the personal information that is collected from its users. Users optionally provide this personal information by choosing details from a drop-down menu on the profiler webpage. Despite the fact that this information is currently collected from users and stored in the Parmenides database, there currently exists no analysis facilities for this information.

Extensions to the Parmenides Analysis Tools to facilitate the collection and analysis of this data could deliver a significant increase in the possible depth of analysis. In the Critique Statistics Analysis tool of Parmenides, the debate administrator can currently see which particular parts of a debate have the most support and which are the most disputed. It is also possible to view the exact number of users who agree and disagree with the positions. However, there is no further information available about these users.

By harnessing the data that is available in the database, the analysis tools could not only display the number of users who agree/disagree with a position, but also the demographic information available about these users. The information could be shown in textual form or even represented graphically to determine demographic trends.

A government could use such a tool to determine whether most of the users who responded in a particular way to a debate fitted a particular demographic profile; and if so, information could be targeted selectively at this audience. For example, consider the following situations related to the speed camera debate example presented in Chapter 5:

The government discover that 80% of respondents to the debate disagree with the fact that "Many drivers break the speed limits". Using the current analysis tools, this is as far as the analysis can go - no further information is available on the users who disagreed. In response to this, the government may decide to send statistics regarding the number of motorists caught speeding every year to all households in the UK, in order to provide support for this fact. However, it may be the case that the majority of the people who disagree that "Many drivers break the speed limits" hold driving licenses. If this information had been available to the government through the analysis tools, then their campaign could have been more specifically targeted by sending the information only to those people who hold driving licenses, rather than all households in the UK.

By way of a second example, consider a situation in which 85% of respondents agree with the statement that "Free Education is a value worth promoting". On first glance, it seems that 85% agreement with this statement is rather good. However, by providing a fine-grained breakdown of this response, it is ascertained that only 30% of those in the "Under 20" age group felt that this was a value worth promoting, with the remaining 70% disagreeing with the statement. In this case, despite the majority agreement with the statement, the government may wish to invest in additional education or advertising aimed towards those under 20 years of age to demonstrate the worthiness of this particular value.

Both of the examples given above illustrate exactly why providing demographic profiling of the respondents to a debate may be desirable. The fact that the system allows users to submit as much or as little information as they wish means that users can participate in such profiling to an extent to which they feel comfortable.

10.4.1.2 Critique Statistics Viewer

The Critique Statistics Viewer interface is envisaged as a web portal which allows users to initially view, and possibly later critique (see Section 10.4.1.3), the opinions submitted by other users of the system. The facility to see the opinions submitted by

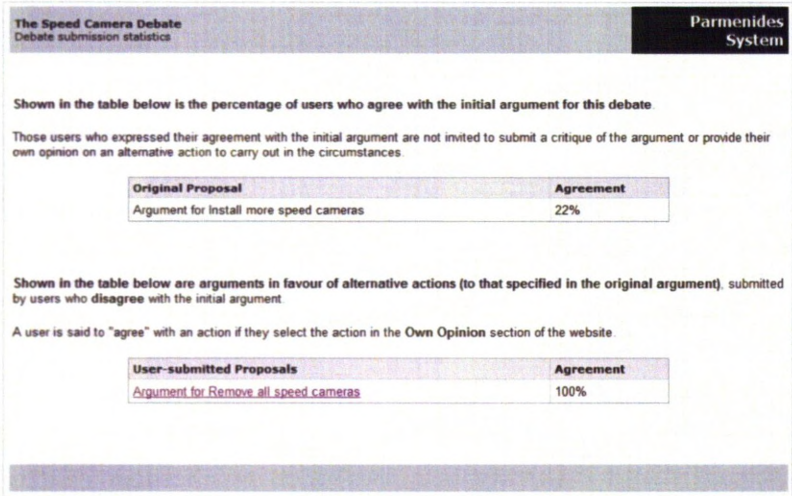


Figure 10.1: Parmenides Statistics Viewer (1)

others, and how their own critique corresponds to these other opinions, could influence users to participate in the system.

By integrating this facility within the Profiler system described in Section 10.4.1.1, a range of facilities could be developed to enhance the data available to users of the system. For example, users could view how the opinions they have submitted correlate with opinions submitted by other users, or with the most popular opinion. This could be integrated with the other demographic profiling information available within the profiling system in order to determine how the user's opinion correlates with other users from a similar demographic background.

To illustrate this, I have created a basic prototype of such a portal as part of my research (although it does not currently integrate with the Profiling System). The prototypical system allows users to visit a webpage on which they are shown what percentage of users agree with the whole position put forward by the government (and hence did not submit a critique), as well as some further information about the alternative opinions submitted by users. This interface is shown in Figure 10.1.

The table towards the top of this screenshot displays the percentage of users that agree with the initial position of the debate. Towards the bottom of the screenshot, a summary of alternative positions put forward by users is displayed, classified according to the actions that they promote. The percentage of users who chose this particular action in their alternative position is displayed to the right. By clicking on the argument, additional information is displayed in the form of the values selected by users as being promoted by carrying out the particular action. For example, Figure 10.2, shows additional information about the action of "Removing all speed cameras on UK roads".

Figure 10.2: Parmenides Statistics Viewer (2)

100% of respondents have stated that this particular action promotes the value of "Saving lives", whilst 50% of users state that it promotes "Public happiness". Again, each of these arguments can be selected in order to see any further arguments which advocate the selected action, promoting the selected value. Any such further arguments will promote an additional value (as users can select more than one value as being promoted in their argument).

An important consideration in implementing a portal such as this is when to present this information to the user. For example, if the user is encouraged to view the data before participating in a debate, then it may influence the critique provided by the user (the user may, for example, be dissuaded from providing an answer which is not shared by many other users). It also opens the system up to the possibility of abuse. By having the ability to see the results stored in the database, users would know which statements hold the current majority agreement. A malicious user could continuously submit opposing critiques to the system until the majority agreement was shifted in the opposite direction.

Here, I have identified the Critique Statistics Viewer as a useful web-based portal that allows participants in a debate to view a summary of the opinions submitted by other users. I have described a prototypical implementation of such a system, and discussed ways in which I feel this could be extended to develop a tool that provides significant analysis facilities.

10.4.1.3 Interactivity Between Arguments

The use of computational tools, especially in conjunction with the Internet, provides a lot of scope for the development of highly interactive systems. The Critique Statistics Viewer described in the previous section is one step towards a more highly interactive system for political engagement.

Additional methods of interactivity could conceivably be implemented within the Parmenides tool. For example, users are currently able to submit their own position of the action that they feel should be carried out in the given circumstances. As this alternative position is also an instantiation of the practical reasoning argumentation scheme, then the critical questions associated with the scheme could be posed against it by other users. This could be combined with the theories of supporting arguments, identified in Chapter 6 and implemented in Parmenides in Chapter 7, to allow for users to represent in-depth support of their own arguments and challenge the arguments of others.

A schematic example of how such an interactive argument chain could form is illustrated in Figure 10.3. Note that the colour applied to the various arguments in this figure is only to distinguish between different proponents, and does not imply any acceptability or otherwise of the respective argument. Within this figure we see the initial position of the debate, as proposed by the government, which suggests the action of installing more speed cameras. An alternative action is posed by a respondent to the debate ("User A"), who suggests that we should actually deploy more traffic police instead (as an instantiation of the practical reasoning argumentation scheme, this argument also proposes a set of consequences and values that are achieved through the performance of this action - these are omitted from the diagram to aid visual clarity). The grey box around these two elements indicates the current limitation of the Parmenides system; argumentation can not proceed beyond this stage. Future enhancements to the system could allow users to support their positions with arguments instantiated using other schemes (a feature currently only available to the proponent of the initial position). In my example argument chain, User A supports his argument by instantiating the "Argument from Expert Opinion" scheme (AS3 in Appendix C).

Another user, identified as "User B" and illustrated by a green box in Figure 10.3, responds to User A's supporting argument by raising one of the critical questions associated with the Expert Opinion scheme. User A has the ability to respond to this criticism if he has a further argument to provide. Meanwhile, User C challenges User A's argument for deploying more traffic police by raising the critical question which suggests that a lower death toll will not be achieved by deploying traffic police. User A then responds to this using the "Argument from Correlation to Cause" scheme (AS8 in Appendix C), stating a correlation between increased traffic police and a decreased roads death toll.

These enhancements to the system would provide a significantly increased level of interactivity, allowing not only critique of the initial position of a debate, but also highly structured discussion of arguments proposed by other users. Proponents of positions would be able to precisely identify the possible shortfalls of their positions as identified by other users. Of course, the implementation of these enhancements would have to be carefully considered in order to avoid the shortfalls in other structured systems identified in Chapter 3.

Additionally, if the system were to be available for use by a large audience, then the analysis of arguments could become confused by long argument chains with many

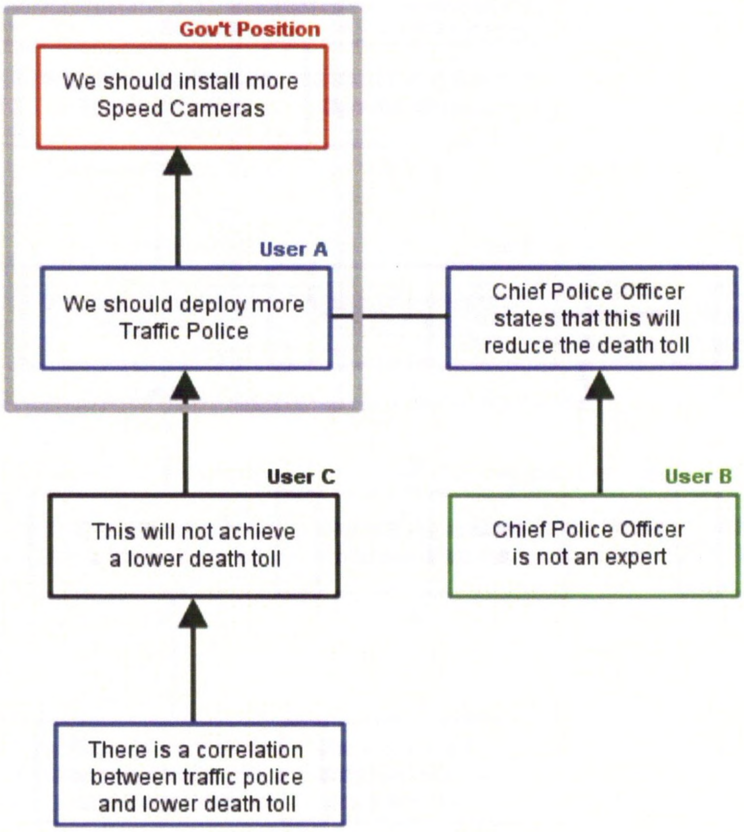


Figure 10.3: Illustration of possible future interaction between arguments within Parmenides, in which arrows indicate attacks

branches. In order to overcome this, some method of grouping and/or summarising the data for the purpose of the visual analysis would need to be developed. This would not be an issue if the system were instead targeted to smaller, representative audiences, as I considered in Section 9.6.

In this section, I considered how interactivity between arguments in the Parmenides system could enhance participation. I also discussed some of the possible shortfalls of implementing such interactivity, and the considerations that would need to be taken into account in order to ensure that these shortfalls do not arise.

10.4.1.4 Improving Expressivity

Parmenides was designed to be a system that provides a trade-off between ease of use and the ability to analyse the collected data computationally. Currently, in order to enable effective analysis of the data collected, Parmenides constrains some elements of the users interaction with the system. Specifically, when submitting their own opinion on a particular action that could be carried out in the context of the debate, the user has to choose their position from a drop-down list of entries.

Overcoming this limitation is a significant task, however I see it as a future research direction which has the potential to significantly enhance user interaction with the system. Natural Language Processing (NLP) is a significant area of Computer Science research (see e.g. [113, 65, 27, 68, 69]). NLP attempts to enable computing technologies to interpret the natural language of humans in a way that allows it to be computationally analysed. One of the aims of research into NLP is to enable computers to detect syntactic differences in written sentences, which may be immediately obvious to a human but are more difficult for a computer to detect. An example given in [69] is of the following two sentences:

'She boarded the plane with two suitcases'

and

'She boarded the plane with two engines'

It is obvious to the average human reader that the suitcases in the first sentence belong to the woman, whereas the engines in the second belong to the aeroplane, but the task of enabling a computer to deal with this kind of ambiguity is an ongoing research task [69].

In the context of Parmenides, the problem that must be addressed by NLP is that when a user submits a free-text element to the Parmenides System (whether this be a statement of circumstance, a suggested action, a consequence or a social value), the system needs to possess the capability to match this with other, similar statements that have been previously submitted. If this is not done, then potentially thousands of responses with identical meanings but different phrasings could be present in the system.

This would create difficulties in analysing the resulting data, potentially resulting in large and confusing analysis frameworks (see for example the Debategraph framework in Section 3.4.1.2). By way of an example, consider the following three examples of alternative positions submitted to The Speed Camera Debate, by three users (named User A, User B, and User C):

User A
Circumstances: Lots of drivers break the speed limits
Action: Install more speed cameras
Social Value: Obeying the law

User B
Circumstances: Too much money is wasted on the installation and maintenance of speed cameras
Action: Get rid of all speed cameras
Social Value: Government wealth

User C
Circumstances: Drivers tend to ignore the highway code
Action: Deploy additional speed cameras
Social Value: Adherance to rules

As humans, we can see that the position of User A and User C are not competing; they both argue for what is essentially the same action of installing more speed cameras on UK roads. However, User B is arguing for an action that is in direct competition with this. A computational tool would have difficulty in determining the mutual support between the positions of User A and User C, and the mutual attack between the position held by these two users and User B.

In addition to classifying sentences which are formulated differently but have essentially the same meaning, Natural Language Processing also has to cater for the fact that a written sentence can have a number of different meanings, dependent upon the intention of the writer. For example, consider the following sentence "I never said she stole my money", which is cited widely throughout the NLP literature. This sentence could have a variety of different meanings, depending on which word the speaker places the stress (indicated by an italic font in the following list):

- "*I* never said she stole my money" - Someone else said it, but I didn't.
- "I *never* said she stole my money" - I simply didn't ever say it.
- "I never *said* she stole my money" - I might have implied it in some way, but I

Figure 10.4: An example of tagging on Flickr

never explicitly said it.

- "I never said *she* stole my money" - I said someone took it; I didn't say it was she.
- "I never said she *stole* my money" - I didn't say she stole it (perhaps she borrowed it).
- "I never said she stole *my* money" - I said she stole someone else's money.
- "I never said she stole my *money*" - I said she stole something of mine, but not my money.

We see from this, that even if the implementation of systems for Natural Language Processing were possible, it relies on the user formulating their response in a way that is largely coherent, not ambiguous, and relevant to the debate. The system would also need possess the capability to identify spam entries, submitted to the system by users who have no intent of making a positive contribution to the debate.

There are other, perhaps easier, research avenues that could be explored in order to address the issue of expressivity. For example, many websites which allow users to define their own content use the concept of "tags" in order to classify contributions. These are typically short phrases of perhaps one or two words that identifies their contribution to the website. An example of a website that uses tags effectively is Flickr[2], a website enabling its users to share photographs and other digital images (see Figure 10.4).

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[2]Flickr: http://www.flickr.com

An implementation of tagging in Parmenides could allow users to enter tags that summarise their contribution, with the software tools classifying contributions that contain similar tags. Alternatively, the tagging of user contributions could be done automatically by extracting phrases from the contributed text. Some literature already exists on the topic of tagging arguments; for example, [126], in which Rahwan discusses how semantic web techniques can be used to annotate arguments in order to "classify", or "identify similarities among", arguments. The CreateDebate website[3], which allows users to participate in user-created debates, recently introduced "Argument Tagging" as a method to "help provide even more structure around [user's] arguments to help distill the central points of each debate"[4].

The methods outlined in this section are open to some degree of scrutiny over how difficult it would be to implement the method, and how it would affect both the usability of the system and the ability to analyse the data within the system. Any enhancement which claims to make the system more expressive must be carefully scrutinised to ensure that it does not breach the finely balanced trade-off between the ease of use by a general audience, and the capability of the system to performed automated analysis on the results.

10.4.2 Argumentation Theories

The discussions so far in this chapter have concentrated on how the features of the Parmenides software tool could be extended. I now turn to consider the theories of argumentation underlying Parmenides, and discuss the future research directions of these structures. I will discuss how future and current development of the underlying argumentation theories could enhance the interaction and analysis features of Parmenides.

10.4.2.1 How Persuasive are Critical Questions?

Currently, within the Parmenides system, all of the critical questions associated with the argumentation scheme are treated equally when it comes to evaluating the argument. In Chapter 6 I discussed my interpretation of how persuasive particular argumentation schemes are in responding to the critical questions of various argumentation schemes. This research could be extended to consider how persuasive each of the critical questions are in attacking the argumentation scheme with which they are associated.

For example, consider the following two questions associated with the "Argument from Expert Opinion" (AS3 in Appendix C):

CQ2: Is E a genuine expert in D?

[3]CreateDebate: http://www.createdebate.com

[4]http://www.createdebate.com/about/newsletters/4

CQ5: Is A supported by evidence?

If we consider a situation in which CQ2 is posed against a particular instantiation of the argumentation scheme, perhaps supported by reasonable evidence to support the claim that E is not a genuine expert, then this is likely to be a very compelling claim for rejection of the whole argument. Now consider an attack posed using CQ5 to suggest that the assertion of the expert is not supported by evidence. This critical question seems far less likely to be worthwhile of rejecting the whole argument, as the critical question simply asserts that there is no evidence to back up the statement of the expert, rather than stating that there is some contrary evidence on which to reject the claim.

The differing strength of critical questions identified in the Expert Opinion scheme is likely to be reflected across all of the schemes described in the literature, including Atkinson's scheme for practical reasoning, on which the Parmenides system is founded. By developing a formal representation of the relative strength of each of these critical questions, it would be possible to refine under exactly what conditions an argument is considered to be "defeated" by the attack of its critical questions.

An implementation of this theory could enhance the argument evaluation facilities. Currently, critiques of the position put forward by the government are analysed only in terms of the number of respondents agreeing or disagreeing with the attacks posed by the critical questions. By combining this data with the relative weighting of each critical question, "defeat" of the initial position would be based on the strength of the attack as well as the number of respondents who agree with it. The ability for the government to adjust the weighting of the critical questions could also be implemented, thus allowing the government to adjust the results of the analysis to reflect their level of concern over each attack.

The persuasiveness of critical questions may also be measured according to exactly where the burden of proof lies in responding to each particular critical question. This, in turn, depends on whether the critical question recognises an *exception* to the use of the scheme, or questions an *assumption* used in the scheme (this distinction is discussed in e.g. [61, 8]). In the case of *exceptions*, the burden of proof is on the opponent, whereas in the case of case of *assumptions*, the burden of proof is on the proponent. In the case of Parmenides, if a respondent to the debate poses a critical question which is an *exception*, but can not provide any evidence to support the attack, then we may wish to classify such an attack as significantly less persuasive than a critical question which questions an *assumption* which the proponent must defend.

Exactly how measures of persuasiveness based on assumptions and exceptions would be implemented is unclear, as the current version of Parmenides only allows the proponent of an argument to supply a supporting argument (thus fulfilling the burden of proof for assumptions), but does not allow respondents to supply an argument in order to pose an exception. However, the discussion presented here provides an interesting avenue for further research and investigation.

10.4.2.2 Developments in Argumentation Frameworks

Argumentation Frameworks, which are discussed in some detail in Section 2.1.2.1, can be used to visualise the relationships between arguments and evaluate these arguments according to the semantics of the framework. Within this thesis, Argumentation Frameworks and Value-based Argumentation Frameworks are used to display the various positions inherent to the debates within the Parmenides System. The frameworks can then be evaluated in order to determine which of the positions can be considered "acceptable" in the context of the debate.

Since the Parmenides analysis toolset was first conceived, there have been a number of research developments which aim to extend the capabilities of Argumentation Frameworks. One example of such is the Extended Argumentation Frameworks (EAFs) described by Modgil in [104].

EAFs allow for the inclusion of arguments that express preferences between other arguments within the framework, thus providing a mechanism to determine whether attacks succeed. The motivation given for the explicit representation of these preferences is that preference information within an AF is often defeasible and conflicting, and hence may itself be subject to argumentation-based reasoning. EAFs extend AFs by introducing a second attack relation, such that an argument which expresses a preference between two other arguments within the framework can attack the binary relationship between these two arguments. This allows one to determine which of the two arguments succeed and hence defeats the other. Arguments which express contradictory preferences can also attack each other, and the "winner" of these two preference arguments can be determined by arguing over which of the preference arguments is preferred and hence defeats the other.

An example of an argument that could be represented in terms of an EAF is presented in [104]. Within this argument, differing weather reports are given by two different television broadcasters (the BBC and CNN). By expressing preferences between these two broadcasters, one can determine which weather report should be believed (i.e. which conflicting position (weather report) should be considered acceptable).

I believe that Extended Argumentation Frameworks could be used within Parmenides in order to enrich both citizen interaction with the system as well as the evaluation of debates carried out by the administrator. There are two ways that I envisage EAFs being used; the first being to reason over elements that are specific to a particular argument. For example, consider two users who have proposed two different actions that could be carried out in the circumstances in order to achieve two different consequences. By providing the debate administrator with the capability to express preferences over the consequences specified by each user, then this would enable an alternative method of reasoning over user-specified debate positions.

The second way in which EAFs could be used is to express preferences over the elements of the argumentation scheme and the associated critical questions. This relates somewhat to the discussion presented in Section 10.4.2.1, where I discussed the possibility of allowing critical questions to be represented with different levels of persuasiveness for the purposes of argument evaluation. By allowing debate administrators to represent levels of preference over critical questions, then the results of the argument analysis could be altered. For example, the government may feel that the issue of whether citizens believe that the circumstances are true is more important than the issue of whether the stated social values are worth promoting. A further extension to EAFs themselves are Argumentation Frameworks with Recursive Attacks (AFRAs), described in [16] as an extension to EAFs in which attacks to attacks can be considered recursively in turn. This is in contrast to EAFs in which attacks on attacks can not be attacked.

Other extensions to AFs have been proposed in addition to the EAF and AFRA described so far in this section. Atkinson and Bench-Capon describe one such extension, named "Abstract Argumentation Scheme Frameworks" in [8]. Abstract Argumentation Scheme Frameworks provide an approach to modeling arguments which combines argumentation schemes and Argumentation Frameworks. This research provides a definition of how the elements of an argumentation scheme can be abstracted to an AF, whilst retaining dialogical aspects of a debate such as burden of proof, and also retaining the evaluation capabilities of Argumentation Frameworks. Atkinson and Bench-Capon provide an example of how multiple arguments can interact using the framework, an area of work that has high relevance to the Parmenides system in which interactions between multiple arguments are now possible. The work seems to present a logical next-step towards improvement of the analysis capabilities of the Parmenides system, and one which could enable further growth of argument interactions by providing a formalism through which they can be effectively visualised and analysed.

Another interesting development is presented by Oren and Norman in [116]. Here, the authors describe a framework which allows for support and attack relationships between arguments to be represented (in contrast to Dung's frameworks, which do not explicitly include the notion of "support" relationships between arguments), and a set of acceptable extensions based on the evidence present within the framework. This is particularly relevant to the work that I presented in Chapter 6, where I developed the groundings of a formal model of how argumentation schemes can interact with each other in order to support and attack facts presented within the arguments.

10.5 Summary

In this chapter, I have summarised the main findings and contributions of my thesis in relation to the aims that I articulated in earlier chapters. I then went on to consider how the software system and underlying theories of argument presented in this thesis could be further expanded in future work, to expand the capabilities of the Parmenides software system. The research presented in this thesis constitutes an early, informative investigation into how formal theories of argument can inform the design of software systems for use by laypersons in an e-Democracy settings to provide complex analysis facilities.

The future work described in Section 10.4 sketches out a landscape rich in emerging ideas which provide real and promising research avenues which could be explored in order to expand the theoretical and software foundations set out in my work. Although there are undoubtedly many obstacles to overcome in the development of usable software in e-Democracy, I believe that the findings reported in this thesis provide the groundwork for these future research avenues to be explored effectively in order to realise a true, effective, electronic democracy.

Appendix A

Evaluation Results

In this appendix, the full results of the evaluations carried out in Chapter 9 are presented. This includes the graphical analysis of critiques and positions submitted by users, and the responses to the questionnaire illustrated both textually and in the form of bar charts.

A.1 Results of Evaluation I

A.1.1 Summary of Respondents

Figure A.1 is a full list of the respondents to the debate ordered by ID number (which is assigned in chronological order, with the first respondent being assigned ID 1). Some processing of the entries had taken place before this screenshot was obtained; namely, responses that I had made myself in order to test the system were removed, and obvious duplicate entries were removed. In order to preserve the privacy of respondents, the "IP" field has been partially obscured.

The final four columns in this figure indicate whether the respondent agreed with the initial position put forward to them ("Agree?"), whether the user submitted a critique of the initial position ("Critique?"), whether an alternative position was submitted ("OwnOpinion?") and whether the user completed the questionnaire at the end of their interaction with the system ("Questionnaire?").

Result Analysis

ID	Name	IP	Agree?	Critique?	OwnOpinion?	Questionnaire?
1	[illegible]	[illegible].81.1	Yes	No	No	No
3	[illegible]	[illegible]220.237	Yes	No	No	No
4	[illegible]	[illegible].80.2	No	Yes	No	No
5	[illegible]	[illegible].134.208	No	Yes	No	Yes
6	[illegible]	[illegible].139.70	No	Yes	No	Yes
7	[illegible]	[illegible].32.12	Yes	No	No	No
8	[illegible]	[illegible].194.91	Yes	No	No	No
9	[illegible]	[illegible].194.91	Yes	No	No	No
10	[illegible]	[illegible].161.23	Yes	No	No	No
11	[illegible]	[illegible].164.200	Yes	No	No	No
13	[illegible]	[illegible].164.200	No	Yes	Yes	No
14	[illegible]	[illegible].163.1	Yes	No	No	No
15	[illegible]	[illegible].230.1	No	Yes	No	No
16	[illegible]	[illegible].93.101	Yes	No	No	No
17	[illegible]	[illegible].93.101	No	Yes	Yes	Yes
18	[illegible]	[illegible].102.1	Yes	No	No	No
19	[illegible]	[illegible].114.99	No	Yes	No	Yes
24	[illegible]	[illegible].46.180	Yes	No	No	No
25		[illegible].46.180	No	Yes	No	Yes
26	[illegible]	[illegible].66.1	Yes	No	No	No
27	[illegible]	[illegible].66.1	No	Yes	No	Yes
29	[illegible]	[illegible].232.1	No	Yes	No	No
30	[illegible]	[illegible].91.1	No	Yes	No	Yes
31	[illegible]	[illegible].125.1	Yes	No	No	No
32	[illegible]	[illegible].125.1	No	Yes	No	Yes
33	[illegible]	[illegible].78.2	Yes	No	No	No
34		[illegible].232.1	No	Yes	No	No
35		[illegible].232.1	No	Yes	No	Yes
36	[illegible]	[illegible].64.1	Yes	No	No	No
37	[illegible]	[illegible].231.1	Yes	No	No	No
38	[illegible]	[illegible].229.1	No	Yes	No	Yes
40		[illegible].126.1	No	Yes	No	No
41		[illegible].126.1		No	No	No
42	[illegible]	[illegible].20.60	Yes	No	No	No
43	[illegible]	[illegible].20.60	No	Yes	Yes	No
44	[illegible]	[illegible].102.60	No	Yes	No	No
45	[illegible]	[illegible]249.195	No	Yes	No	No
46	[illegible]	[illegible]2.240.2	No	Yes	No	No
47	[illegible]	[illegible].145.1	Yes	No	No	No
48	[illegible]	[illegible].145.1	No	Yes	No	No
49	[illegible]	[illegible].145.1	No	Yes	No	No

Figure A.1: Overview of respondents to Evaluation 1

A.1.2 Critique Responses

Figures A.2 to A.6 present the output of the Parmenides Analysis Critique Statistics tool. This tool allows for collation and evaluation of the critique of the initial position provided by respondents.

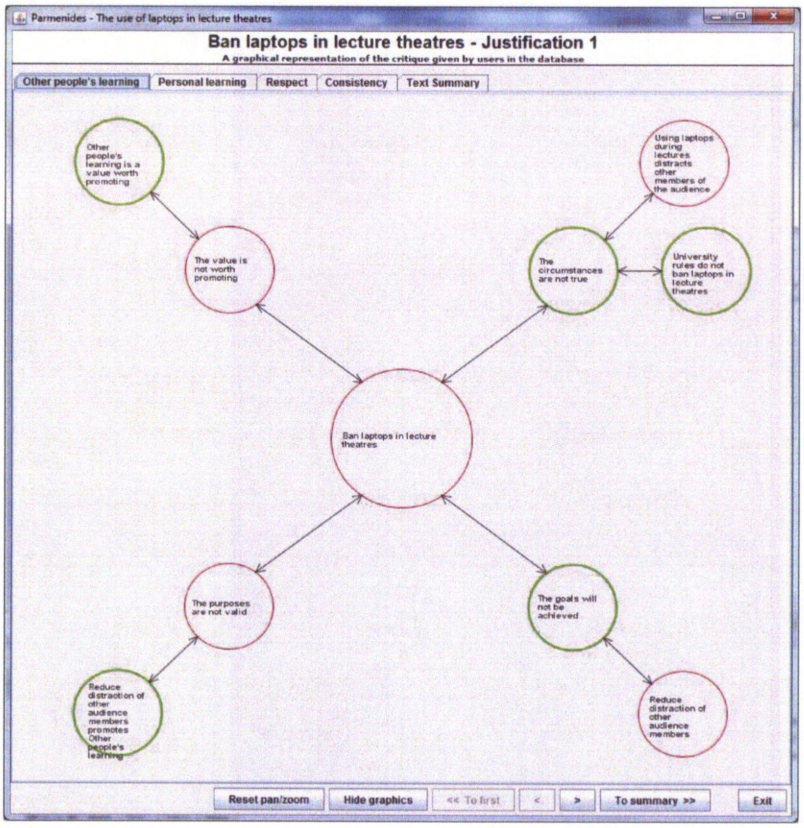


Figure A.2: Parmenides critique statistics analysis for Evaluation 1 (1)

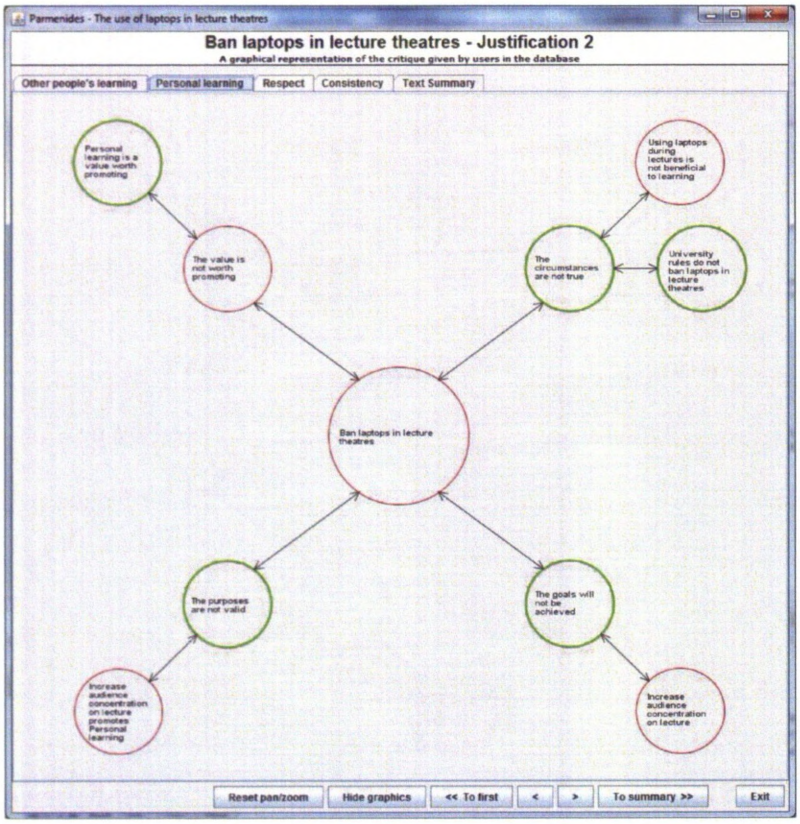


Figure A.3: Parmenides critique statistics analysis for Evaluation 1 (2)

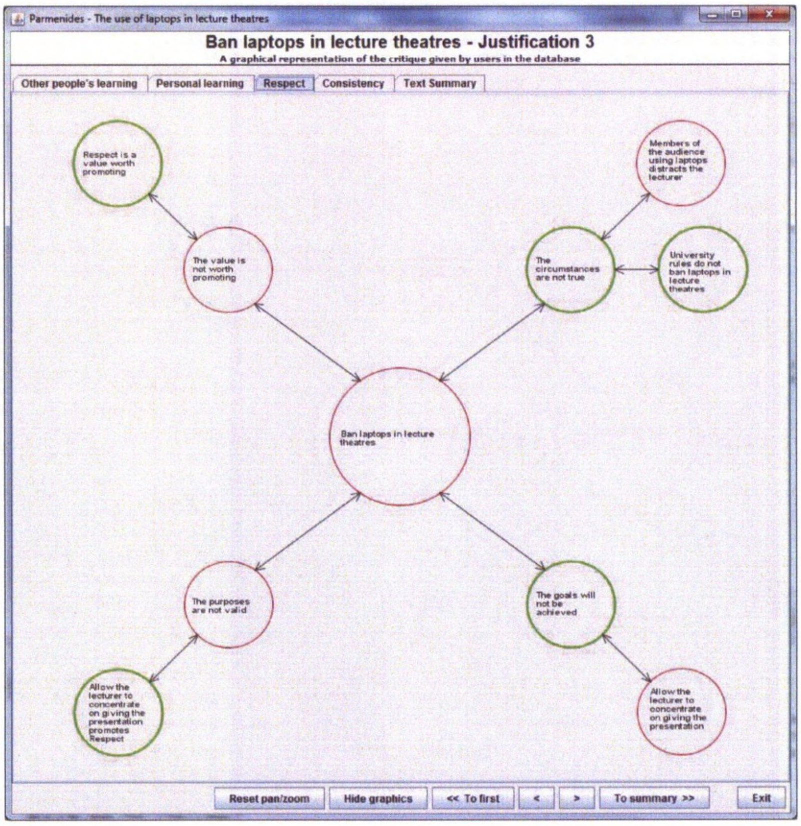


Figure A.4: Parmenides critique statistics analysis for Evaluation 1 (3)

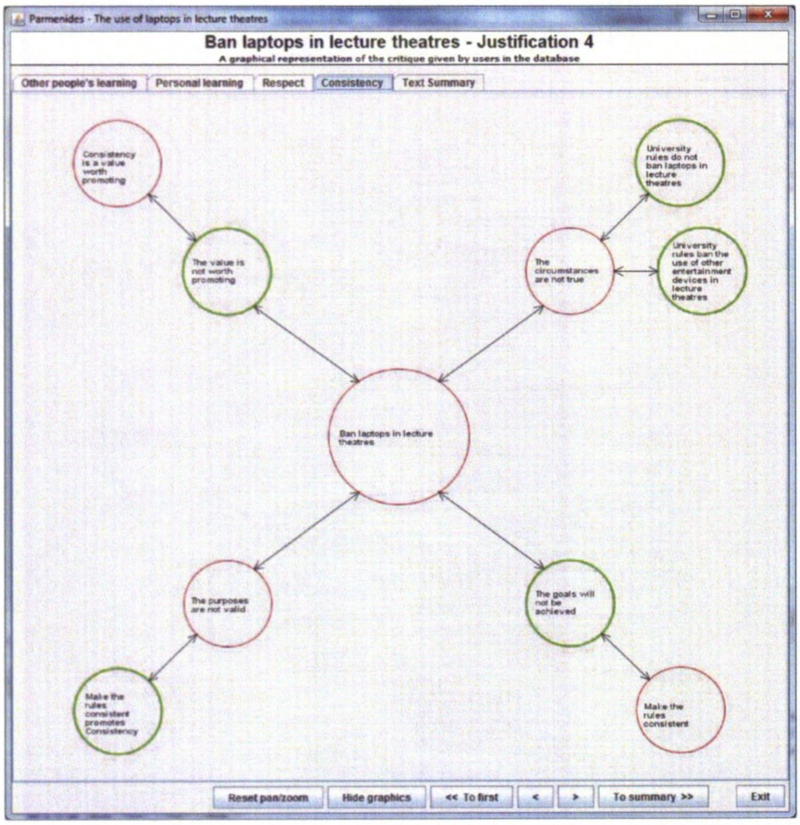


Figure A.5: Parmenides critique statistics analysis for Evaluation 1 (4)

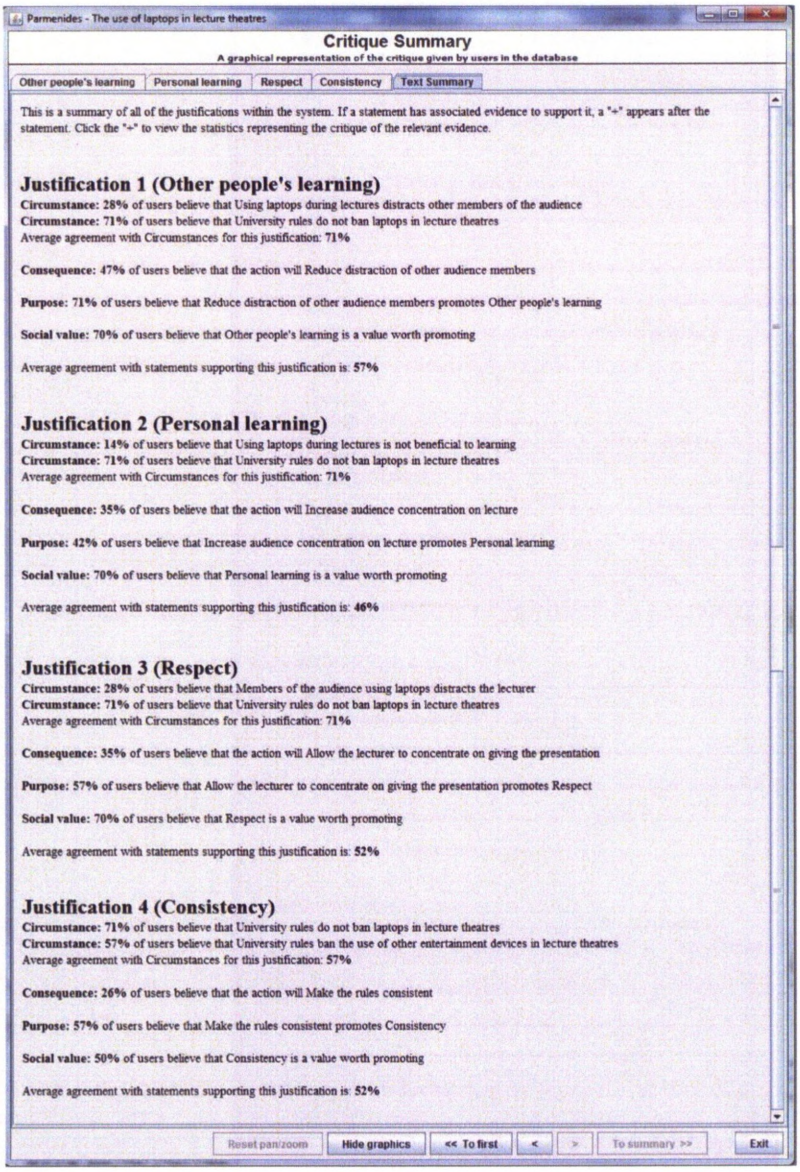


Figure A.6: Parmenides critique statistics analysis for Evaluation 1 - Textual results

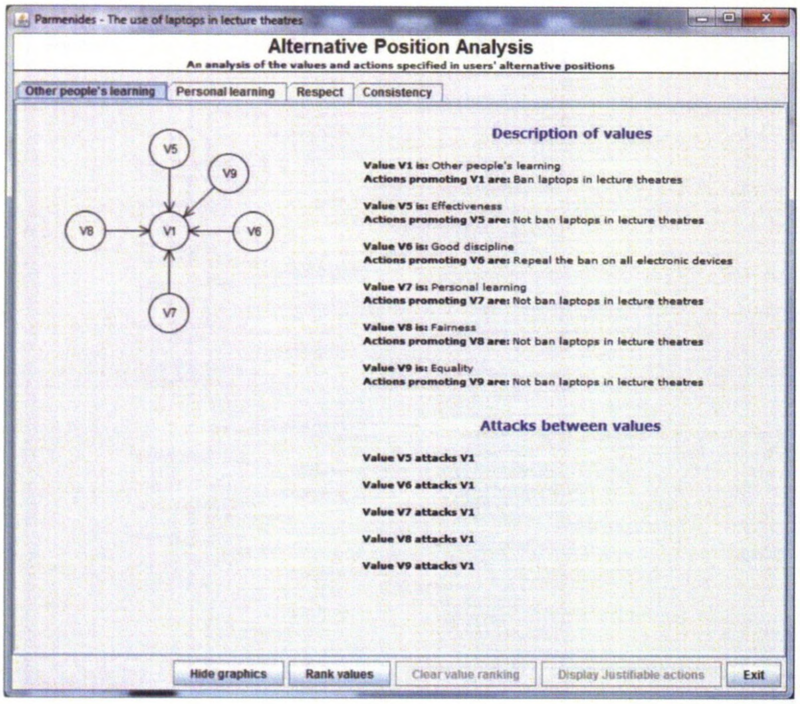


Figure A.7: Parmenides alternative position analysis for Evaluation 1

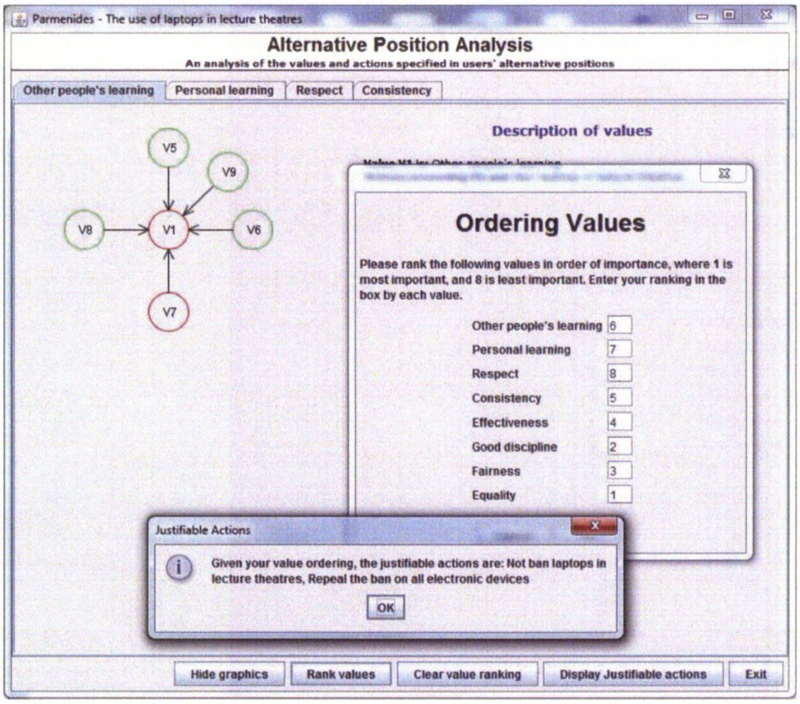


Figure A.8: Example of value ordering to obtain justifiable alternative actions - Evaluation 1

A.1.3 Response to Questionnaire

Although the responses to the questionnaire were presented and discussed previously in Section 9.4.1.2, they are reproduced here for completeness:

1. How easy did you find it to understand the difference between the elements of the proposal (e.g. circumstances, consequences, social values)?
    - No response: 10%
    - Very easy: 10%
    - Easy: 20%
    - Neutral: 40%
    - Difficult: 10%
    - Very difficult: 10%
2. How easy did you find it to express exactly why you disagree with the proposal?
    - No response: 10%
    - Very easy: 0%
    - Easy: 30%
    - Neutral: 30%
    - Difficult: 30%
    - Very difficult: 0%
3. Did being able to see the constituent parts of the proposal make it easier to focus on your specific reasons for disagreement?
    - No response: 10%
    - Yes, definitely: 30%
    - Yes, a little: 40%
    - Neutral: 0%
    - No, not noticeably: 20%
    - No, definitely not: 0%
4. Did the fact that you couldn't enter free-text responses restrict your ability to respond appropriately?
    - No response: 10%
    - Yes, definitely: 20%
    - Yes, a little: 20%

- Neutral: 30%
- No, not noticeably: 20%
- No, definitely not: 0%

5. Did you submit an alternative position after critiquing the proposal presented? No response (10%), Yes (0%), No (90%)

    - No response: 10%
    - Yes: 0%
    - No: 90%

    If No to Q5:

    (a) Please tell us why you didn't submit an alternative position:

    - Did not have an alternative position in mind: 44%
    - Did not have time: 44%
    - Did not see the option: 0%
    - Did not understand how to use it: 0%
    - Other: 11%

6. Have you previously used websites that gather public opinion?

    - No response: 20%
    - Yes: 50%
    - No: 30%

    If Yes to Q6:

    (a) Which kinds of website have you used?

    - e-Petitions: 60%
    - News story responses: 20%
    - Individual blog responses: 40%
    - Opinion polls: 100%
    - Online surveys: 80%
    - Item review websites: 60%
    - Other: 0%

    (b) How often (on average) do you use such websites?

    - Daily: 40%
    - Weekly: 0%

- Monthly: 20%
- Less than Monthly: 40%

(c) How does Parmenides compare to these other websites, overall?

- No response: 20%
- Much better: 0%
- Slightly better: 0%
- About the same: 40%
- Slightly worse: 40%
- Much worse: 0%

If No to Q6:

(a) Has the Parmenides website encouraged you to share your opinions more often?

- No response: 0%
- Yes, definitely: 0%
- Yes, a little: 33%
- Neutral: 67%
- No, not noticeably: 0%
- No, definitely not: 0%

7. Would you use Parmenides again?
   - No response: 10%
   - Yes: 30%
   - Unsure: 50%
   - No: 10%

8. Would you use Parmenides regularly to participate in opinion polls that are relevant to your life?
   - No response: 10%
   - Yes: 40%
   - Unsure: 50%
   - No: 0%

Some users also provided free-text responses in the additional comment box present on the questionnaire. These are as follows:

Do you have any other suggestions or comments related to Parmenides?

- *There are some text boxes that appear at some point where one does not really know what to put there.*
- *Pose questions that make sense: e.g. Purpose: "Increase audience concentration on lecture promotes Personal learning". Correct answer: not necessarily. I could agree to "Increase audience concentration on lecture does not diminish Personal learning"*

A.2 Results of Evaluation II

In this section I present the full results of both phases of the second evaluation, described in Section 9.5 of my thesis.

A.2.1 Phase 1

A.2.1.1 Summary of Respondents

Figure A.1 is a full list of the respondents to the debate ordered by ID number.

The final four columns in this figure indicate whether the respondent agreed with the initial position put forward to them ("Agree?"), whether the user submitted a critique of the initial position ("Critique?"), whether an alternative position was submitted ("OwnOpinion?") and whether the user completed the questionnaire at the end of their interaction with the system ("Questionnaire?").

Result Analysis

ID	Name	IP	Agree?	Critique?	OwnOpinion?	Questionnaire?
0	[illegible]	[illegible]27.211	Yes	No	No	No
1	[illegible]	[illegible]35.179	No	Yes	No	No
2	[illegible]	[illegible]219.117	No	Yes	No	No
3	[illegible]	[illegible]193.160	No	Yes	No	Yes
4	[illegible]	[illegible]244.121	No	Yes	Yes	Yes
8	[illegible]	[illegible]35.179	No	Yes	No	Yes
9	[illegible]	[illegible]109.229	No	Yes	No	Yes
11	[illegible]	[illegible].37.37	No	Yes	Yes	Yes
12	[illegible]	[illegible]3.7.37	No	Yes	Yes	Yes
14	[illegible]	[illegible].81.197	Yes	No	No	No
15	[illegible]	[illegible].24.112		No	No	No
16	[illegible]	[illegible].78.73	No	Yes	No	Yes
17	[illegible]	[illegible].37.39	No	Yes	No	Yes
18	[illegible]	[illegible].95.17	No	Yes	Yes	Yes
19	[illegible]	[illegible].2.62	No	Yes	No	Yes

Figure A.9: Overview of respondents to Evaluation 2, Phase 1

A.2.1.2 Critique Responses

Figures A.10 to A.13 present the output of the Parmenides Analysis Critique Statistics tool for the second phase of the second evaluation.

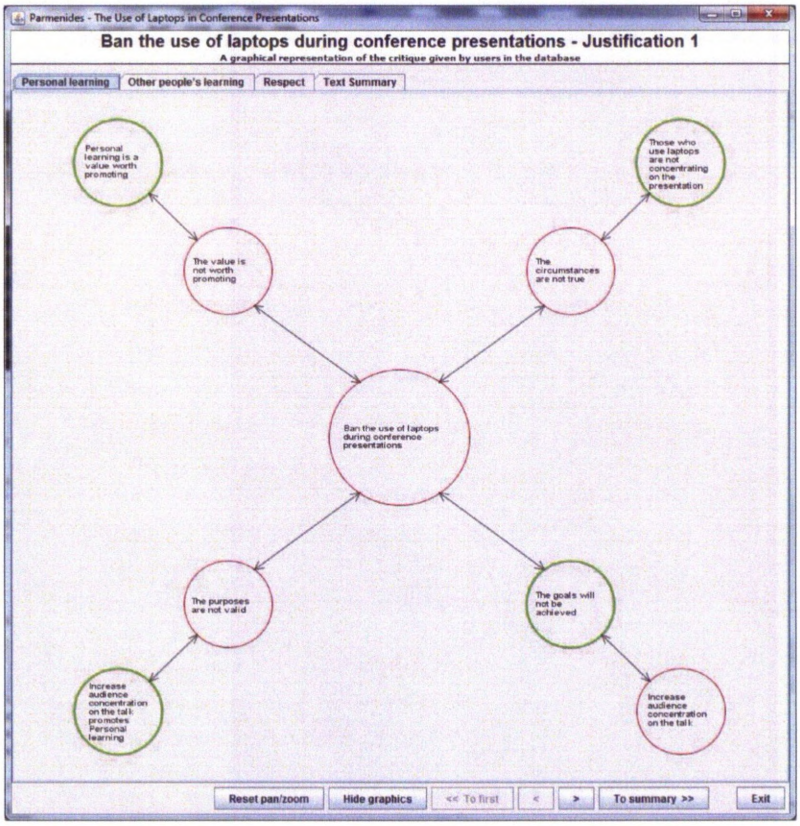


Figure A.10: Parmenides critique statistics analysis for Evaluation 2, Phase 1 (1)

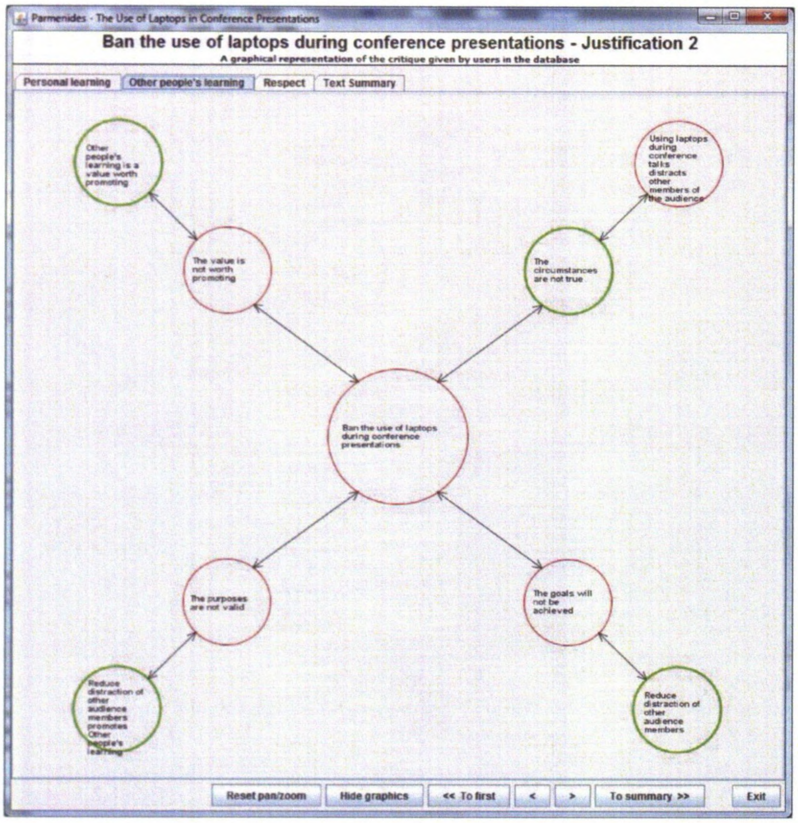


Figure A.11: Parmenides critique statistics analysis for Evaluation 2, Phase 1 (2)

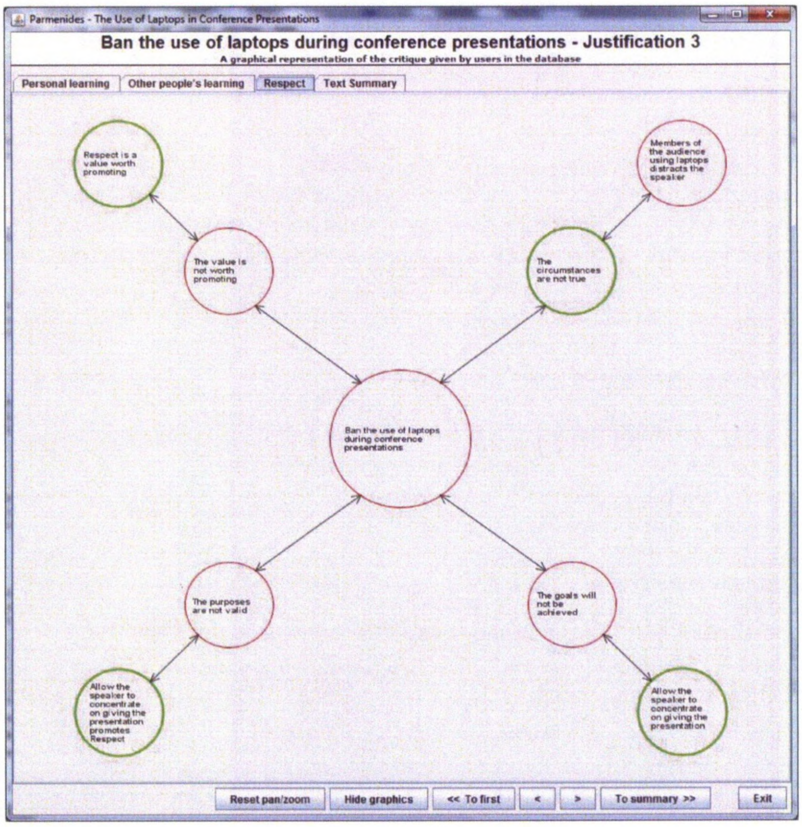


Figure A.12: Parmenides critique statistics analysis for Evaluation 2, Phase 1 (3)

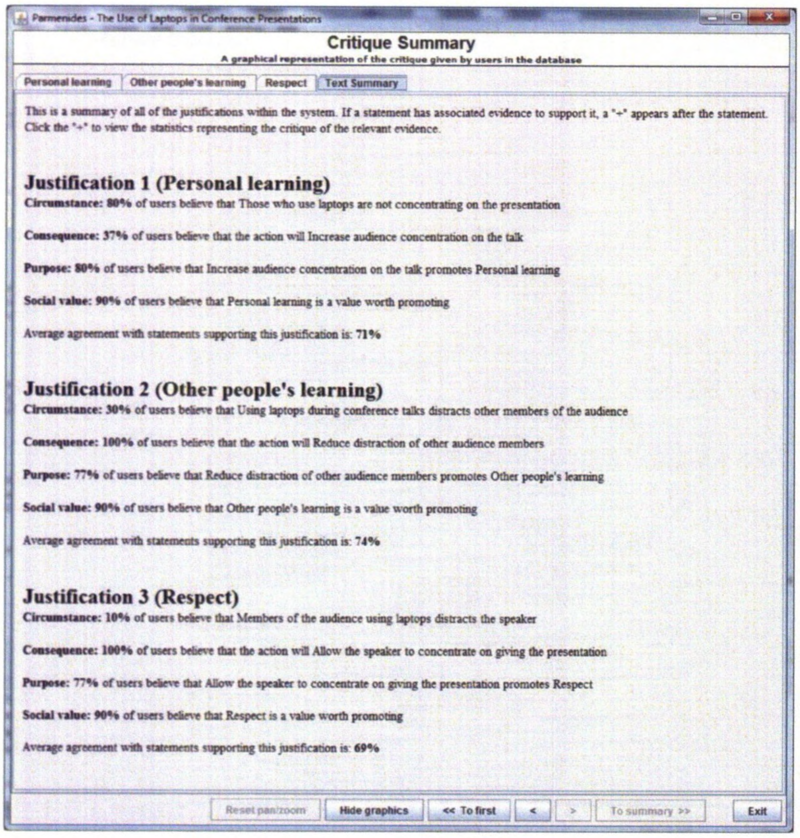


Figure A.13: Parmenides critique statistics analysis for Evaluation 2, Phase 1 - Textual results

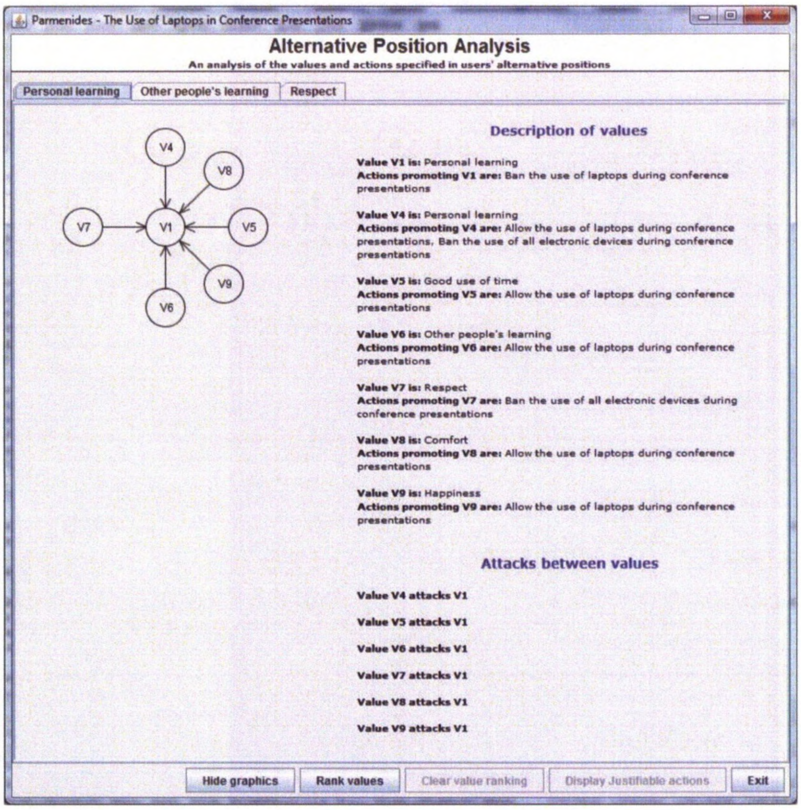


Figure A.14: Parmenides alternative position analysis for Evaluation 2, Phase 1

A.2.1.3 Response to Questionnaire

Although the responses to the questionnaire were presented and discussed previously in Section 9.4.1.2, they are reproduced here for completeness:

1. How easy did you find it to understand the difference between the elements of the proposal (e.g. circumstances, consequences, social values)?
   - No response: 10%
   - Very easy: 10%
   - Easy: 60%
   - Neutral: 20%
   - Difficult: 0%
   - Very difficult: 0%
2. How easy did you find it to express exactly why you disagree with the proposal?
   - No response: 10%
   - Very easy: 0%
   - Easy: 40%
   - Neutral: 20%
   - Difficult: 30%
   - Very difficult: 0%
3. Did being able to see the constituent parts of the proposal make it easier to focus on your specific reasons for disagreement?
   - No response: 10%
   - Yes, definitely: 20%
   - Yes, a little: 30%
   - Neutral: 10%
   - No, not noticeably: 30%
   - No, definitely not: 0%
4. Did the fact that you couldn't enter free-text responses restrict your ability to respond appropriately?
   - No response: 10%
   - Yes, definitely: 10%
   - Yes, a little: 50%

- Neutral: 0%
- No, not noticeably: 30%
- No, definitely not: 0%

5. Did you submit an alternative position after critiquing the proposal presented?

   - No response: 10%
   - Yes: 40%
   - No: 50%

   If No to Q5:

   (a) Please tell us why you didn't submit an alternative position:

      - Did not have an alternative position in mind: 80%
      - Did not have time: 0%
      - Did not see the option: 0%
      - Did not understand how to use it: 0%
      - Other: 20%

   If Yes to Q5:

   (a) Did you feel you were able to express your opinion sufficiently?

      - No response: 0%
      - Yes, definitely: 25%
      - Yes, a little: 75%
      - Neutral: 0%
      - No, not noticeably: 0%
      - No, definitely not: 0%

6. Have you previously used websites that gather public opinion?

   - No response: 10%
   - Yes: 60%
   - No: 30%

   If Yes to Q6:

   (a) Which kinds of website have you used?

      - e-Petitions: 50%
      - News story responses: 33%

- Individual blog responses: 33%
- Opinion polls: 50%
- Online surveys: 83%
- Item review websites: 33%
- Other: 0%

(b) How often (on average) do you use such websites?

- Daily: 0%
- Weekly: 33%
- Monthly: 17%
- Less than Monthly: 50%

(c) How does Parmenides compare to these other websites, overall?

- No response: 17%
- Much better: 0%
- Slightly better: 17%
- About the same: 33%
- Slightly worse: 33%
- Much worse: 0%

If No to Q6:

(a) Has the Parmenides website encouraged you to share your opinions more often?

- No response: 0%
- Yes, definitely: 0%
- Yes, a little: 33%
- Neutral: 33%
- No, not noticeably: 33%
- No, definitely not: 0%

7. Would you use Parmenides again?

- No response: 10%
- Yes: 50%
- Unsure: 40%
- No: 0%

8. Would you use Parmenides regularly to participate in opinion polls that are relevant to your life?

- No response: 10%
- Yes: 10%
- Unsure: 40%
- No: 40%

Some users also provided free-text responses in the additional comment box present on the questionnaire. These are as follows:

- **Do you have any other suggestions or comments related to Parmenides?**

  1. *Why did you not explore the use of the value-based arg model to support on-line dialogue? The way the questionnaire is structured tends to force the user into a specific set of values and a specific argument for a proposition. Why not explore how a system can help someone form such a structure. So, you may provide a list of values that are relevant to the topic, ask which are promoted/demoted by a specific action, allow the user to explore the effects of certain actions, etc., and, through that, enable the user to form an argument that can be put into a debate. It would then be interesting to see how a reasoning engine could then identify commonalities/ disputes from individuals' contributions.*
  2. *From the interface point of view, provide a Back button (if you press something by mistake). From the argumentation point of view, it was not clear to me if when I was asked to list 'consequences' I needed to include only consequences which had the same orientation of the proposal, or whether I could also include "adverse side effects".*
  3. *The sharp distinction between goals and values is arbitrary; sometimes a chain of subgoals is better (but I may be biased by my own research). Better overview is needed at any point in the interaction, e.g. with argument visualisation techniques. Sometimes degrees instead of binary yes-no answers are desirable (e.g. laptops sometimes or somewhat distract the audience).*
  4. *I did not find the fact that I could not enter free-text response to be too restricting. However, what I did find made it difficult to understand the question sometimes is that the questions have a very strict Practical reasoning format, i.e. "do you think action would improve value". I think some of the question would be easier to understand if they were phrased more naturally.*
  5. *At times I felt like I needed to know what Parmenides was going to ask me *next* in order to answer the question at hand. It was a little unclear also when, and to what extent, the things I added in were going to be available*

subsequently (i.e. whether they'd be appearing in drop down boxes later on).

6. *Either provide a "Back" button, or warn that it won't be available.*
7. *The first page, which asks whether the user agrees with everything in the position statement doesn't make it clear whether one is agreeing with the elements of the position statement or the conclusion that the proposed policy is best. There may be alternative, better policies, even if all of the statements in the position are true.*

- **Do you have any suggestions or comments related to online opinion gathering systems in general?**

    1. *Opinion gathering systems where responses are predefined (like most of the opinion polls, not necessarily on-line) can more easily be manipulated to obtain the results one wants from the audience. One would expect the more advanced, AI based tools, could at least try to avoid this, if their main aim is to increase the level of public debate.*

A.2.2 Phase 2

A.2.2.1 Summary of Respondents

Figure A.1 is a full list of the respondents to the debate ordered by ID number.

The final four columns in this figure indicate whether the respondent agreed with the initial position put forward to them ("Agree?"), whether the user submitted a critique of the initial position ("Critique?"), whether an alternative position was submitted ("OwnOpinion?") and whether the user completed the questionnaire at the end of their interaction with the system ("Questionnaire?").

Result Analysis

ID	Name	IP	Agree?	Critique?	OwnOpinion?	Questionnaire?
9	[illegible]	[illegible].81.197	No	Yes	No	Yes
10	[illegible]	[illegible].80.143	No	Yes	Yes	No
11	[illegible]	[illegible].80.143	No	Yes	No	Yes
12	[illegible]	[illegible].147.10		Yes	No	No
5	[illegible]	[illegible].137.251	No	Yes	Yes	No
4	[illegible]	[illegible].137.251	No	Yes	Yes	Yes
1	[illegible]	[illegible].137.251	No	Yes	Yes	Yes
2	[illegible]	[illegible].137.251	No	Yes	Yes	Yes
3	[illegible]	[illegible].137.251	No	Yes	Yes	Yes
0	[illegible]	[illegible].137.251	No	Yes	Yes	Yes

Figure A.15: Overview of respondents to Evaluation 2, Phase 2

A.2.2.2 Critique Responses

Figures A.16 to A.5 present the output of the Parmenides Analysis Critique Statistics tool for the second phase of the second evaluation.

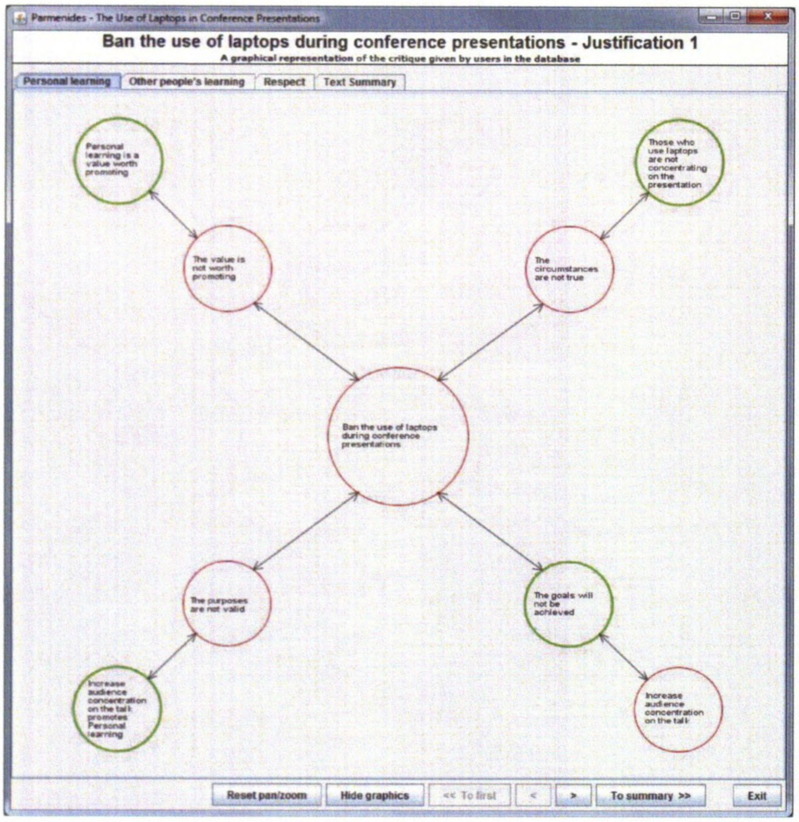


Figure A.16: Parmenides critique statistics analysis for Evaluation 2, Phase 2 (1)

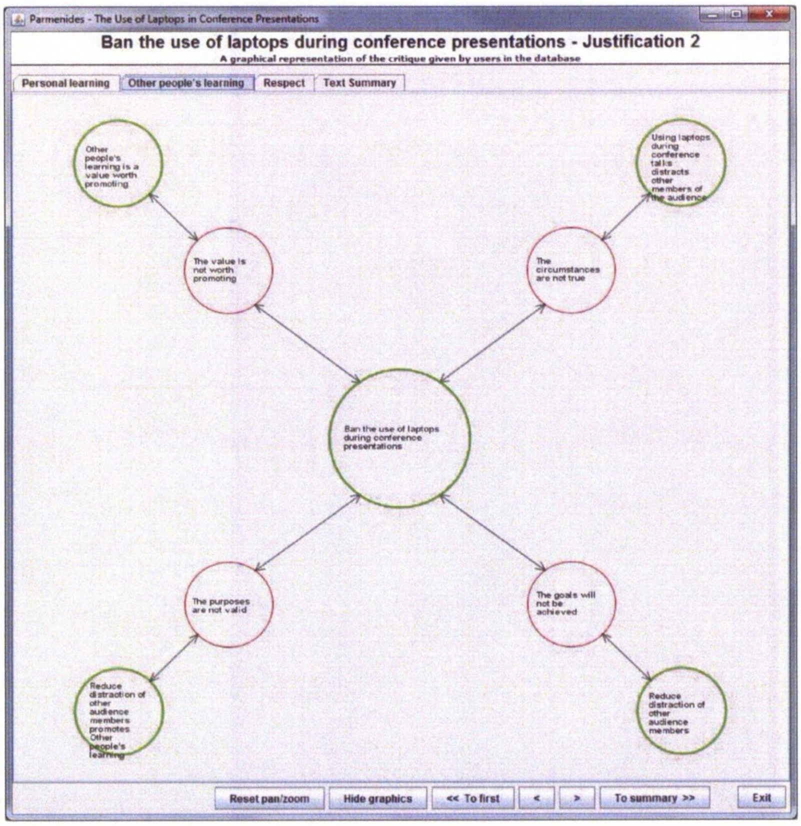


Figure A.17: Parmenides critique statistics analysis for Evaluation 2, Phase 2 (2)

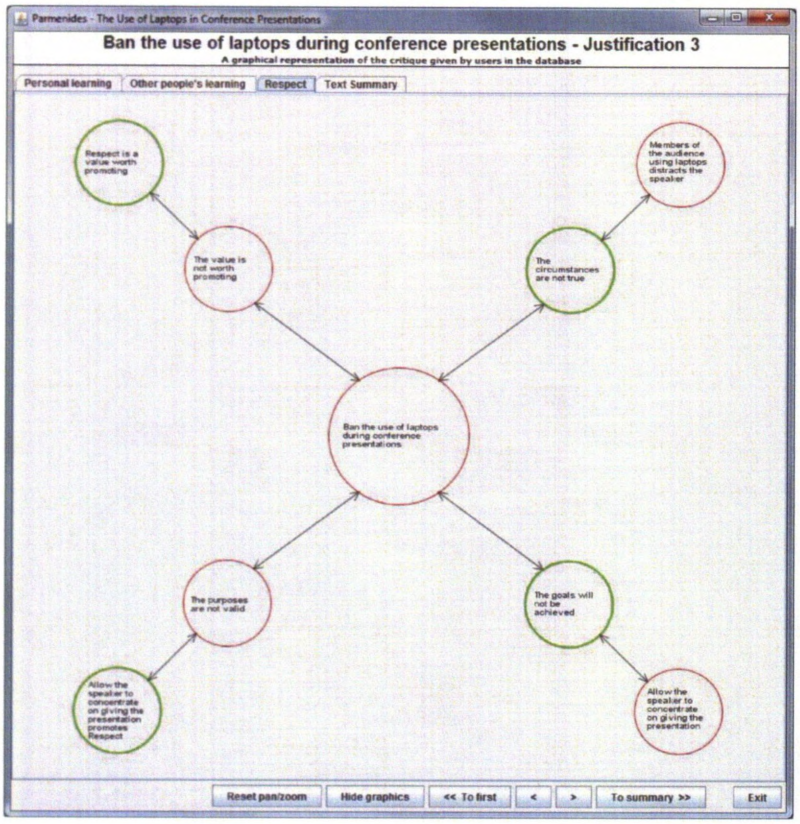


Figure A.18: Parmenides critique statistics analysis for Evaluation 2, Phase 2 (3)

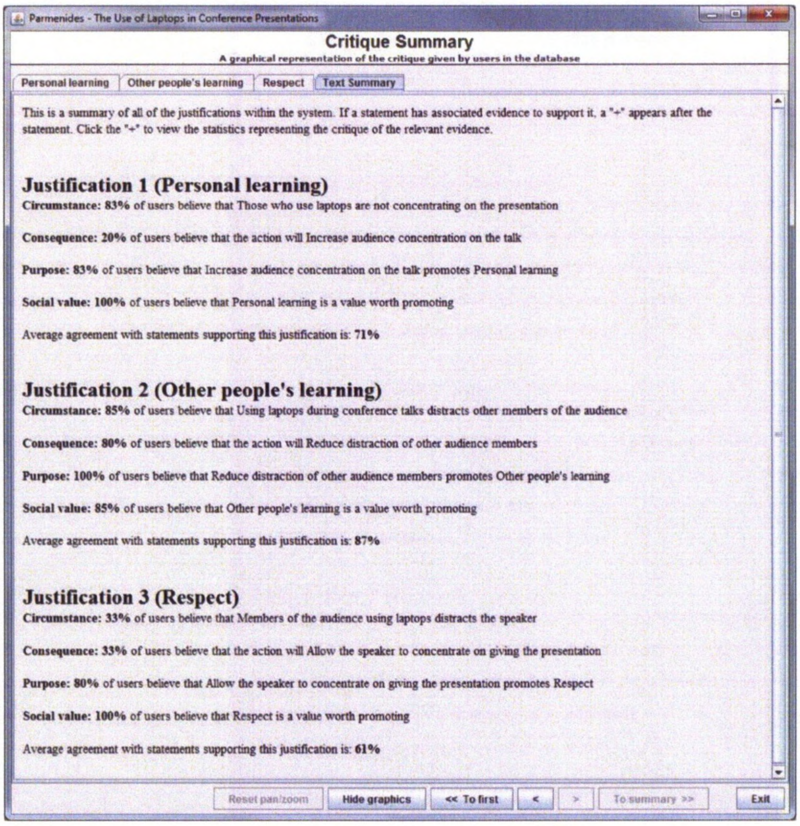


Figure A.19: Parmenides critique statistics analysis for Evaluation 2, Phase 2 - Textual results

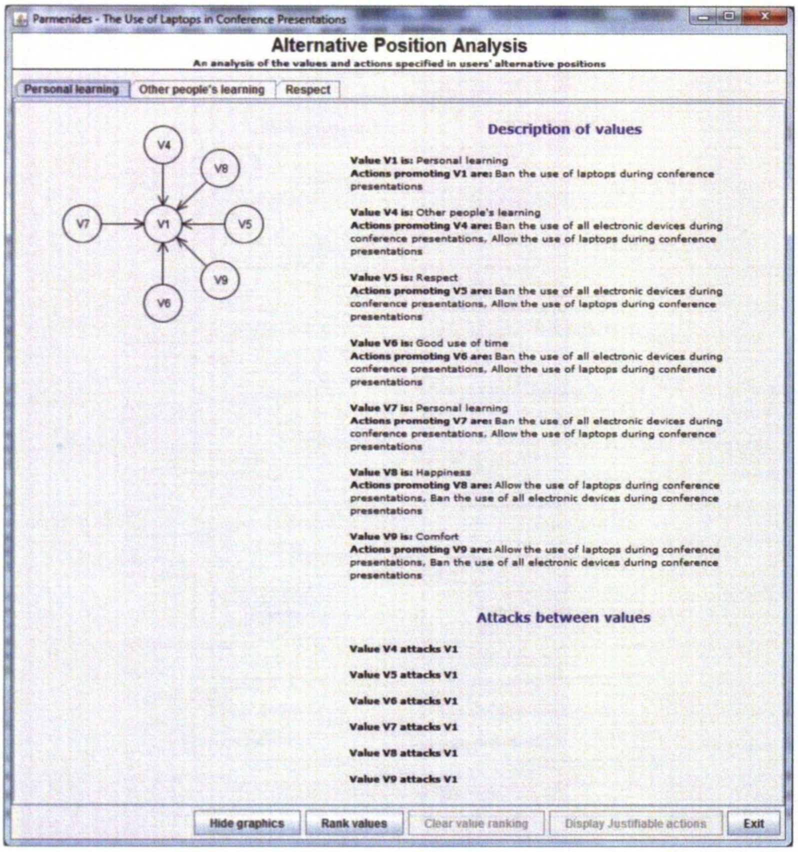


Figure A.20: Parmenides alternative position analysis for Evaluation 2, Phase 2

A.2.2.3 Response to Questionnaire

Although the responses to the questionnaire were presented and discussed previously in Section 9.4.1.2, they are reproduced here for completeness:

1. How easy did you find it to understand the difference between the elements of the proposal (e.g. circumstances, consequences, social values)?
   - No response: 14%
   - Very easy: 43%
   - Easy: 60%
   - Neutral: 14%
   - Difficult: 29%
   - Very difficult: 0%
2. How easy did you find it to express exactly why you disagree with the proposal?
   - No response: 14%
   - Very easy: 29%
   - Easy: 43%
   - Neutral: 20%
   - Difficult: 14%
   - Very difficult: 0%
3. Did being able to see the constituent parts of the proposal make it easier to focus on your specific reasons for disagreement?
   - No response: 14%
   - Yes, definitely: 29%
   - Yes, a little: 29%
   - Neutral: 29%
   - No, not noticeably: 0%
   - No, definitely not: 0%
4. Did the fact that you couldn't enter free-text responses restrict your ability to respond appropriately?
   - No response: 14%
   - Yes, definitely: 0%
   - Yes, a little: 29%

- Neutral: 0%
- No, not noticeably: 43%
- No, definitely not: 14%

5. Did you submit an alternative position after critiquing the proposal presented?

   - No response: 14%
   - Yes: 57%
   - No: 29%

   If No to Q5:

   (a) Please tell us why you didn't submit an alternative position:

   - Did not have an alternative position in mind: 100%
   - Did not have time: 0%
   - Did not see the option: 0%
   - Did not understand how to use it: 0%
   - Other: 0%

   If Yes to Q5:

   (a) Did you feel you were able to express your opinion sufficiently?

   - No response: 0%
   - Yes, definitely: 75%
   - Yes, a little: 0%
   - Neutral: 25%
   - No, not noticeably: 0%
   - No, definitely not: 0%

6. Have you previously used websites that gather public opinion?

   - No response: 14%
   - Yes: 14%
   - No: 71%

   If Yes to Q6:

   (a) Which kinds of website have you used?

   - e-Petitions: 100%
   - News story responses: 100%

- Individual blog responses: 100%
- Opinion polls: 100%
- Online surveys: 100%
- Item review websites: 100%
- Other: 0%

(b) How often (on average) do you use such websites?

- Daily: 0%
- Weekly: 0%
- Fortnightly: 100%
- Monthly: 0%
- Less than Monthly: 0%

(c) How does Parmenides compare to these other websites, overall?

- No response: 0%
- Much better: 0%
- Slightly better: 0%
- About the same: 100%
- Slightly worse: 0%
- Much worse: 0%

If No to Q6:

(a) Has the Parmenides website encouraged you to share your opinions more often?

- No response: 0%
- Yes, definitely: 20%
- Yes, a little: 0%
- Neutral: 60%
- No, not noticeably: 20%
- No, definitely not: 0%

7. Would you use Parmenides again?

- No response: 14%
- Yes: 57%
- Unsure: 29%
- No: 0%

8. Would you use Parmenides regularly to participate in opinion polls that are relevant to your life?

   - No response: 14%
   - Yes: 29%
   - Unsure: 29%
   - No: 29%

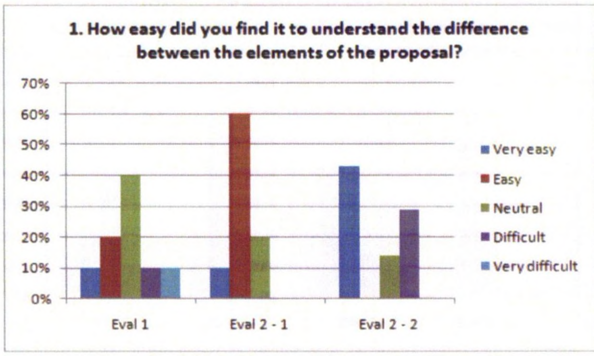
Some users also provided free-text responses in the additional comment box present on the questionnaire. These are as follows:

- **Do you have any other suggestions or comments related to Parmenides?**

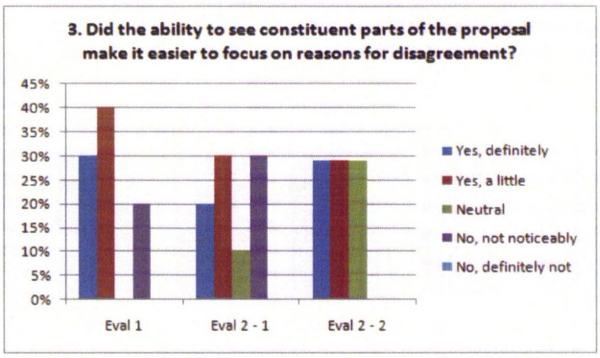
  1. *The only particular improvement that came to mind was to do with having to keep the information in mind across the different web pages. For example when it asks you about the goals, I had to think for a minute about which bit of the scheme you meant.*
  2. *In 'Our Position, I think it would be handier and easier if the different reasons for the proposal would be presented as different reasons rather than as 1 huge argument. For example: Argument 1: We want to allow the speaker to concentrate. However, laptops distract. Banning laptops results in the speaker to be better able to concentrate. Argument 2: We want to reduce distraction for others, however, laptop distract. Banning laptops would result in others to better able to concentrate. In other parts, some statements are too blunt. For example, in 'Circumstances' you must say whether 'those who use laptops are not concentrating on the presentation' is true or false. However, I think this is typically the case, but not always. Some who use laptops do know very well what the presentation is about.*

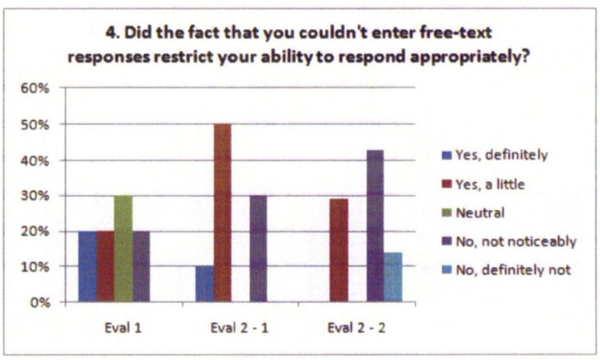
A.3 Graphical Analysis of Questionnaire Responses

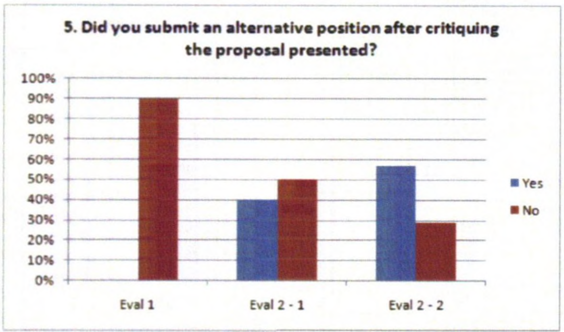
Here, I present the response to the questionnaire for all three evaluations in the form of bar charts. This representation allows for the trends present in the data to be easily visualised.

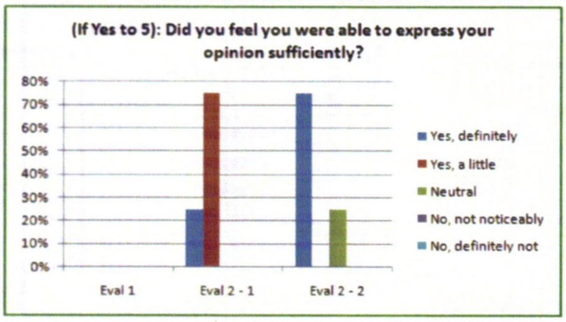

1. How easy did you find it to understand the difference between the elements of the proposal?
70%
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Very easy
Easy
Neutral
Difficult
Very difficult

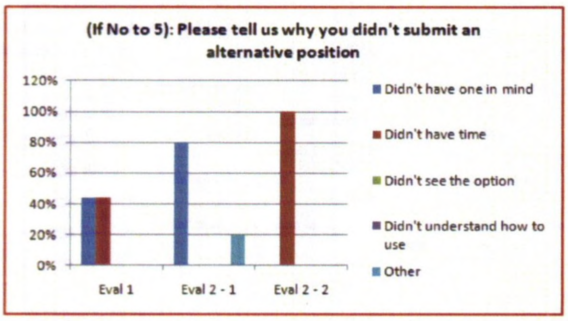

2. How easy did you find it to express exactly why you disagree with the proposal?
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Very easy
Easy
Neutral
Difficult
Very difficult

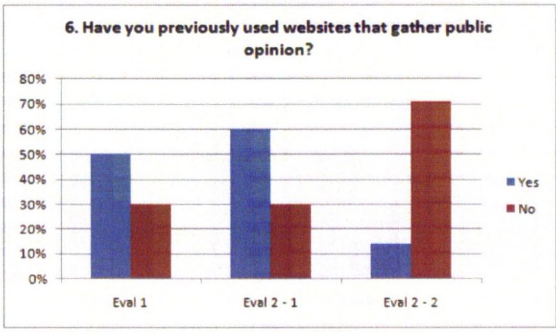

3. Did the ability to see constituent parts of the proposal make it easier to focus on reasons for disagreement?
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Yes, definitely
Yes, a little
Neutral
No, not noticeably
No, definitely not

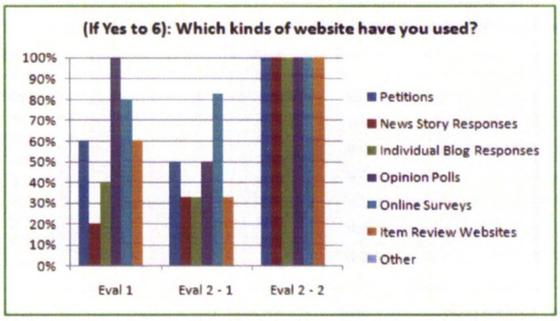

4. Did the fact that you couldn't enter free-text responses restrict your ability to respond appropriately?
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Yes, definitely
Yes, a little
Neutral
No, not noticeably
No, definitely not

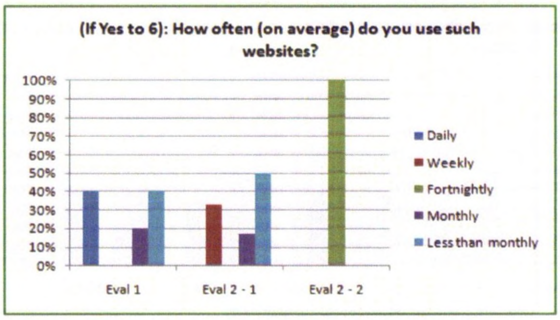

5. Did you submit an alternative position after critiquing the proposal presented?
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Yes
No

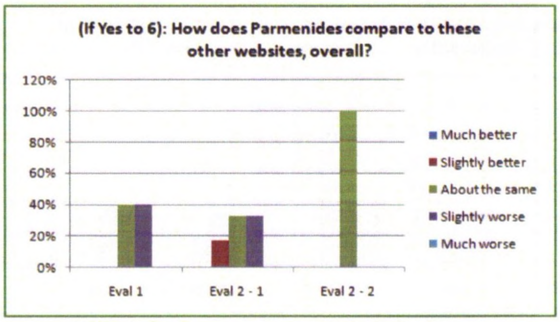

(If Yes to 5): Did you feel you were able to express your opinion sufficiently?
80%
70%
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Yes, definitely
Yes, a little
Neutral
No, not noticeably
No, definitely not

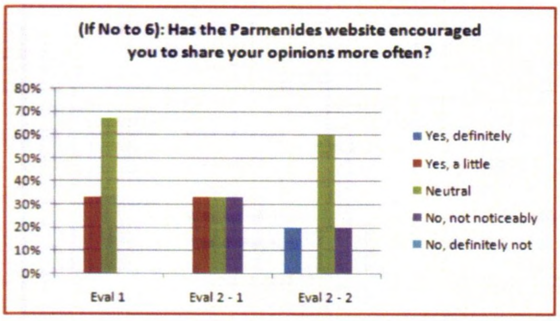

(If No to 5): Please tell us why you didn't submit an alternative position
120%
100%
80%
60%
40%
20%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Didn't have one in mind
Didn't have time
Didn't see the option
Didn't understand how to use
Other

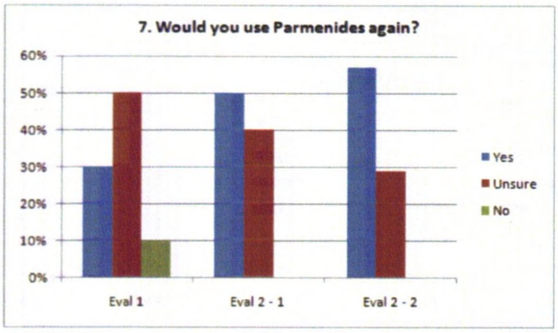

6. Have you previously used websites that gather public opinion?
80%
70%
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Yes
No

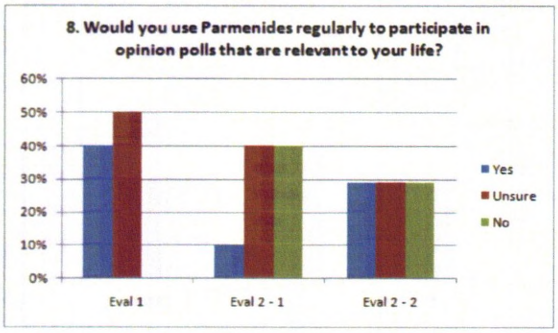

(If Yes to 6): Which kinds of website have you used?
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Petitions
News Story Responses
Individual Blog Responses
Opinion Polls
Online Surveys
Item Review Websites
Other


(If Yes to 6): How often (on average) do you use such websites?
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Daily
Weekly
Fortnightly
Monthly
Less than monthly


(If Yes to 6): How does Parmenides compare to these other websites, overall?
120%
100%
80%
60%
40%
20%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Much better
Slightly better
About the same
Slightly worse
Much worse


(If No to 6): Has the Parmenides website encouraged you to share your opinions more often?
80%
70%
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Yes, definitely
Yes, a little
Neutral
No, not noticeably
No, definitely not


7. Would you use Parmenides again?
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Yes
Unsure
No


8. Would you use Parmenides regularly to participate in opinion polls that are relevant to your life?
60%
50%
40%
30%
20%
10%
0%
Eval 1
Eval 2 - 1
Eval 2 - 2
Yes
Unsure
No

Appendix B

Software Design Documentation

In this appendix I present the design documentation for the implementation of the Parmenides system. The system consists of three separate components, each of which are discussed in turn. In Section B.2 I provide the design documentation for the Java-based Parmenides Analysis tools, followed by the Parmenides PHP/HTML website in Section B.3 and the design for the SQL database in Section B.4.

B.1 Relationship Between Software Sub-Systems

As part of my research, I have developed a number of separate software entities which interact not only with the users of the system, but also with each other in order to support the entire debate life cycle. Figure B.1 illustrates the relationships between the separate software entities which comprise the Parmenides System[1].

B.2 Parmenides Java Application

In this section I provide design documentation for the Parmenides Java application.

B.2.1 Class Diagram

Figure B.2 presents a primitive UML class diagram, which shows the classes that comprise the Parmenides application and the relationship between these classes. In addition to the classes displayed here, the application also makes use of a large range of the predefined classes from the Java Applications Programming Interface (API). Although these classes are necessary in order for the program to function correctly, they are not

[1]Note that this figure does not conform to any UML notation, rather it is intended as a primitive illustration of the relationship between software systems and files within Parmenides

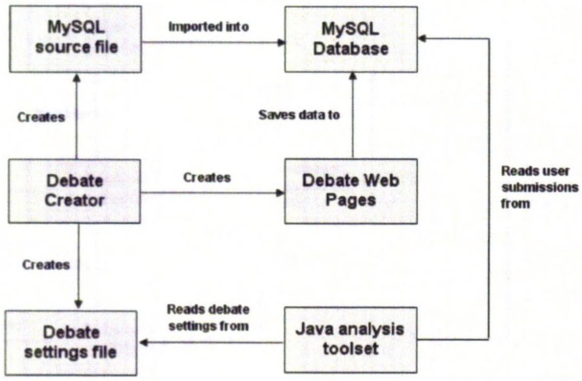


Figure B.1: The Parmenides System - Relationships Between Software Entities

the main focus of the implemented system are hence are omitted from this diagram in order to aid visual clarity.

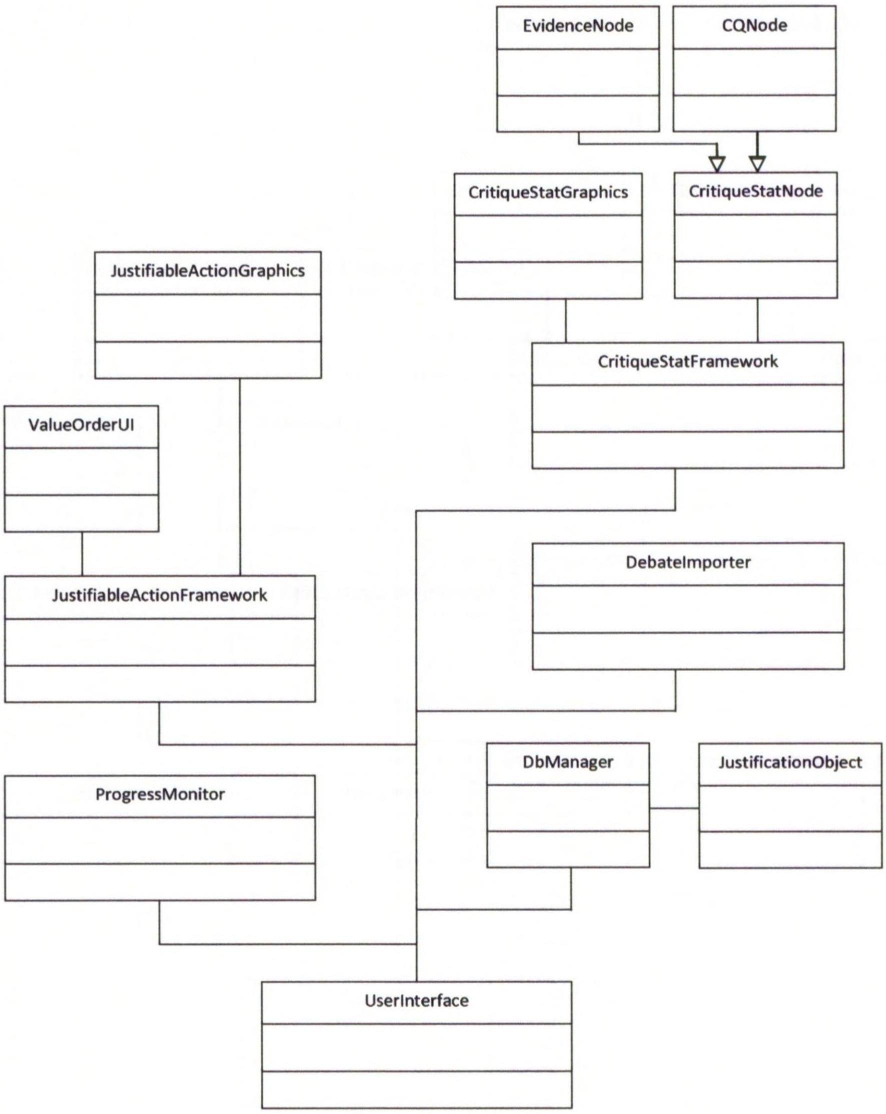


Figure B.2: Parmenides Java Application - Class Diagram

In the below tables I elaborate the class diagram in Figure B.2 with the fields, constructors and methods and attributes contained within each of the classes shown.

UserInterface
private int initPosStats[] private Properties newProps private JustificationObject justifications[]
public UserInterface() public void loadDebate(Object) public void chooseContext() public void chooseDebate() private void showArgumentIntro() public void run()

Table B.1: Parmenides Java Application - *UserInterface* class

ProgressMonitor
private boolean loadFinished private int progress
public ProgressMonitor() public void setTaskLength(int) public void updateProgress(int) public void run()

Table B.2: Parmenides Java Application - *ProgressMonitor* class

DbManager
private String username private String password private String url private Properties instanceProps private ProgressMonitor parmenidesProgressMonitor private int noInitialValues private ResultSet opinionDbResults private int numRowsOpinion
public int[] returnAgreeDisagreeStats() public JustificationObject[] returnCritiqueStats() private ResultSet returnEvidence() private int[][] returnEvidenceStats() private ResultSet getOpinionData() private ResultSet getEvidenceData() private String getValue(int, int, ResultSet) private String getAction(int, ResultSet) private int getOpinionID(int, ResultSet) private int determineNoValues(ResultSet) private int determineNoRows(ResultSet)

Table B.3: Parmenides Java Application - *DbManager* class

JustificationObject
private ArrayList circumstances private ArrayList consequences private ArrayList purposes private ArrayList values
public justificationObject(int) public void addCirc(String, int, int) public void addCons(String, int, int) public void addPur(String, int, int) public void addValue(String, int, int) public void addEvidence(int, String[], String, int) public ArrayList returnCircs() public ArrayList returnCons() public ArrayList returnPurs() public ArrayList returnVal()

Table B.4: Parmenides Java Application - *JustificationObject* class

DebateImporter
private JFrame parentFrame
public DebateImporter() public void showImporter() private File fileChooser() private int doImport(File) private int addToDebateList(String) private int copyPropertiesFile(File, String)

Table B.5: Parmenides Java Application - *DebateImporter* class

JustifiableActionFramework
private ArrayList values private String initialAction private String debateName private final int XOFFSET private int currentVal private int noVals private boolean valuesRanked private VafNode[] nodeArray private VafNode[] initialVafNodeArray private Properties instanceProps private JFrame mainFrame private JButton clear private JButton displayJustifiableActions
public JustifiableActionFramework(ValueAction[], Properties) public JSplitPane createFramework(int) private String constructTextSidebar(int) private void constructVafNodeArray() private void clearRanking() private void displayJustifiableActions() private void showFrameworkIntro() public void newVafNodeArray(VafNode[], VafNode[])

Table B.6: Parmenides Java Application - *JustifiableActionFramework* class

JustifiableActionGraphics
private VafNode[] nodeArray private VafNode[] initialVafNodeArray private int initialValue
public JustifiableActionGraphics(int, VafNode[], VafNode[]) private void drawFramework(Graphics, int) private boolean drawAttack(Graphics, VafNode, VafNode) private void drawArrow(Graphics, int, int, int, int) private void drawInitialValue(Graphics, VafNode) public void paintComponent(Graphics)

Table B.7: Parmenides Java Application - *JustifiableActionGraphics* class

VafNode
private ArrayList attackingNodes public int ovalID public int locationID private boolean isOut private boolean isInitial private int ranking
public VafNode(String) public void setInitial() public boolean isInitial() public void addActionArray(ArrayList) public void setRank(int) public int getRank() public void setNotOut() public boolean isOut() public void addAttackingNode(Node) public void clearStaleData()

Table B.8: Parmenides Java Application - *VafNode* class

ValueOrderUI
private JTextField textArray[][] private VafNode[] nodeArray private VafNode[] initialVafNodeArray private ArrayList displayedValues
public ValueOrderUI(JustifiableActionFramework, VafNode, VafNode) private int getUniqueValues() public void createUI() private void returnOrdering() private boolean validateEntries()

Table B.9: Parmenides Java Application - *ValueOrderUI* class

CritiqueStatFramework
private JustificationObject[] justifications private String[] values private int noValues private JFrame mainFrame private JButton back private JButton next private JButton toFirst private JButton summary private JButton resetGfx private Properties instanceProps private String debateName private String action private JTabbedPane tabbedPane private CritiqueStatGraphics[] gfxArray
public CritiqueStatFramework(JustificationObject[], Properties) public void createMainUI() private void setButtons() private JScrollPane showTextSummary() private String constructTextSummary() public void createEvidencePopup(int, int, int)

Table B.10: Parmenides Java Application - *CritiqueStatFramework* class

CritiqueStatGraphics
private int valueNo private Graphics2D g2 public ArrayList elementNodeStorage public ArrayList cqNodeStorage public ArrayList evidenceNodeStorage private ArrayList nodesInStorage private ArrayList expandedNodes private Properties instanceProps private String action protected double translateX protected double translateY protected double scale private int nodeOffsets protected double resizeFactorX protected double resizeFactorY private double initialPanelWidth private double initialPanelHeight
public CritiqueStatGraphics(int, JustificationObject[], String[][][], Properties) public void resetDimensions() private void panelResized() private void drawFramework(Graphics) private void drawNode(Graphics, int, int, int, boolean) private int drawEvidenceNode(Graphics, int, int, int, int, String) private int drawElementNode(Graphics, int, int, int, int, int, String, int) private int drawCQNode(Graphics, int, int, int, int, int, String, String, int) private int drawFannedNode(Graphics, int, int, int, ArrayList, int) private void writeInNode(String, Graphics, int, int, int, int) private void drawArrow(Graphics, int, int, int, int, int) private void addEvidence(Graphics, int, int, int, int[][], int) protected void requestNodeExpansion(int) private void createCQFan(Graphics, int, int, int, int, int) public void paint(Graphics)

Table B.11: Parmenides Java Application - *CritiqueStatGraphics* class

CritiqueStatNode
protected double noPeopleAgree protected double noPeopleDisagree protected double totalOpins protected int nodeLocation
public CritiqueStatNode(Ellipse2D.Double, int, int, int, String) public boolean containsPoint(Point) public String getPercAgree() public String getPercDisagree() public int getTotalSample() public int getX() public int getY() public int returnNodeLoc() public String returnUniqueID()

Table B.12: Parmenides Java Application - *CritiqueStatNode* class

CQNode
public CQNode(Ellipse2D.Double, int, int, int, String, String) public String getText()

Table B.13: Parmenides Java Application - *CQNode* class

EvidenceNode
public EvidenceNode(Ellipse2D.Double, int, int, int, String) public String getStatement()

Table B.14: Parmenides Java Application - *EvidenceNode* class

B.2.2 Debate Information Files

Within the Java toolset, "debate information files" are used to store information about debates that are operational within the system. These files have a ".ini" extension to signify that they are application configuration files. The files are created by the Parmenides Debate Creator, and can then be saved to the working directory of the Parmenides Java application in order to allow the application to analyse the resulting debate data.

Within the debate information files are a number of *parameters* which describe the features of the particular debate. Each parameter consits of the *name* of the parameter and the *value* of the paramater. For example *debateName = "The Speed Camera Debate"* is a parameter in which the value of *debateName* is *The Speed Camera Debate.*

The full listing of parameters within each debate information file is as follows:

- **debateName** - The name of the debate
- **questionPosed** - The question posed by the debate (e.g. *Should we install more speed cameras?*)
- **initAction** - The action proposed by the proponent of the debate (e.g. *Install more speed cameras*)
- **noInitVals** - The number of justifications present in the debate
- **userAgreesValue** - The text stored in the database, where the user agrees with a critical question (default: *Yes*)
- **userDisagreesValue** - The text stored in the database, where the user disagrees with a critical question (default: *No*)
- **noValSpecifiedValue** - The text stored in the database, where the user does not specify a response (default: *(None)*)
- **sqlDb** - Name of the database in which responses are stored
- **sqlHostWebsite** - Name of the SQL host, to be used by the Parmendies website
- **sqlUserWebsite** - The SQL username, to be used by the Parmendies website
- **sqlPassWebsite** - The SQL password, to be used by the Parmendies website
- **sqlHostJava, sqlUserJava, sqlPassJava** - As above, to be used by the Parmendies java application
- **userTable** - Name of the SQL table storing user information for this debate
- **opinionTable** - Name of the SQL table storing user-created positions for this debate

- **critiqueTable** - Name of the SQL table storing critiques given by users for this debate
- **evidenceTable** - Name of the SQL table storing evidence specified by debate administrator, for this debate
- **evidenceAnsTable** - Name of the SQL table storing user responses to the evidence specified by debate administrator, for this debate
- **schemesTable** - Name of the SQL table storing details of the argumentation schemes used within Parmenides
- **cqTable** - Name of the SQL table storing critical questions for each of the argumentation schemes used within Parmenides
- **just*x*Circ*y*** - The text of circumstance y in justification x of this debate
- **just*x*Circ*y*Field** - The database field storing responses to circumstance y in justification x of this debate
- **just*x*Cons*y*** - The text of consequence y in justification x of this debate
- **just*x*Cons*y*Field** - The database field storing responses to consequence y in justification x of this debate
- **just*x*Pur*y*** - The text of purpose y in justification x of this debate
- **just*x*Pur*y*Field** - The database field storing responses to purpose y in justification x of this debate
- **just*x*Val** - The text of the social value in justification x of this debate
- **just*x*ValField** - The database field storing responses to the social value in justification x of this debate
- **noOpCircs** - The number of circumstance statements users can choose from in the alternative position section of the website
- **noOpCons** - The number of consequence statements users can choose from in the alternative position section of the website
- **noOpActs** - The number of action statements users can choose from in the alternative position section of the website
- **noOpVals** - The number of social value statements users can choose from in the alternative position section of the website
- **opCirc*x*** - The text of circumstance x in the alternative positions section of the website

- **opCons$x$** - The text of consequence x in the alternative positions section of the website
- **opAct$x$** - The text of action x in the alternative positions section of the website
- **opVal$x$** - The text of social value x in the alternative positions section of the website

B.3 Parmenides PHP-based Website

In this section, I provide design documentation which describes the operation of the Parmenides webpages. Figures B.3 and B.4 illustrate the paths through the Parmenides debate participation webpages, whilst Figure B.5 relates to the Parmenides Profiler and Figure B.6 relates to the Parmenides Debate Creator web interface.

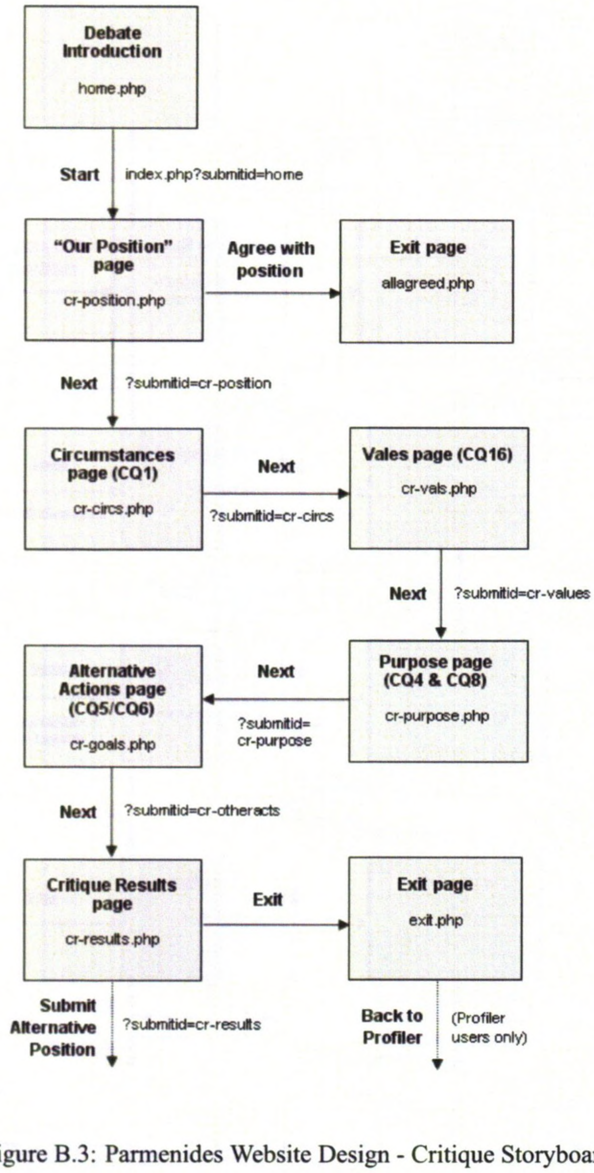


Figure B.3: Parmenides Website Design - Critique Storyboard

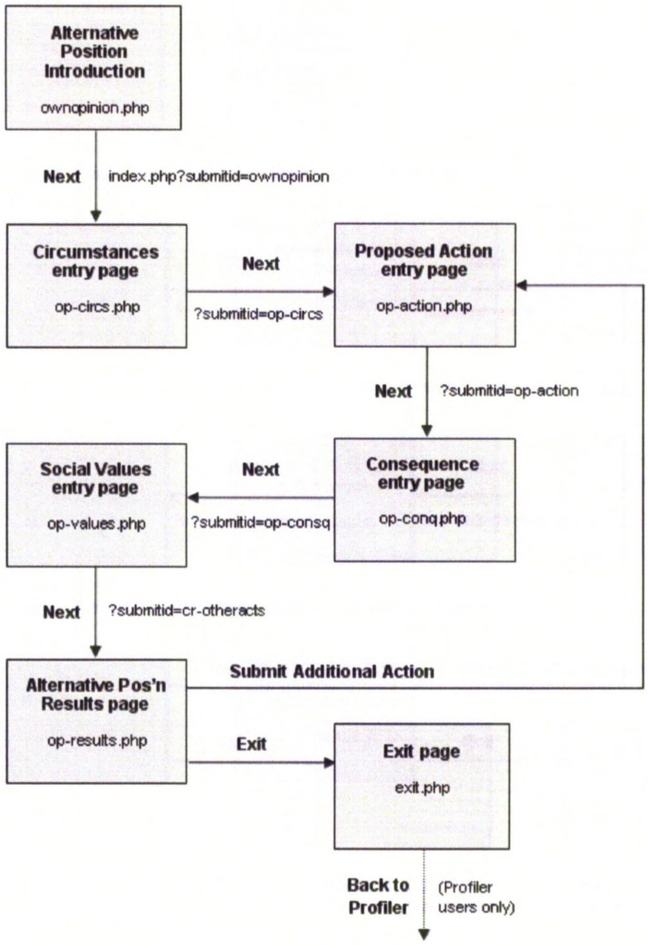


Figure B.4: Parmenides Website Design - Alternative Position Storyboard

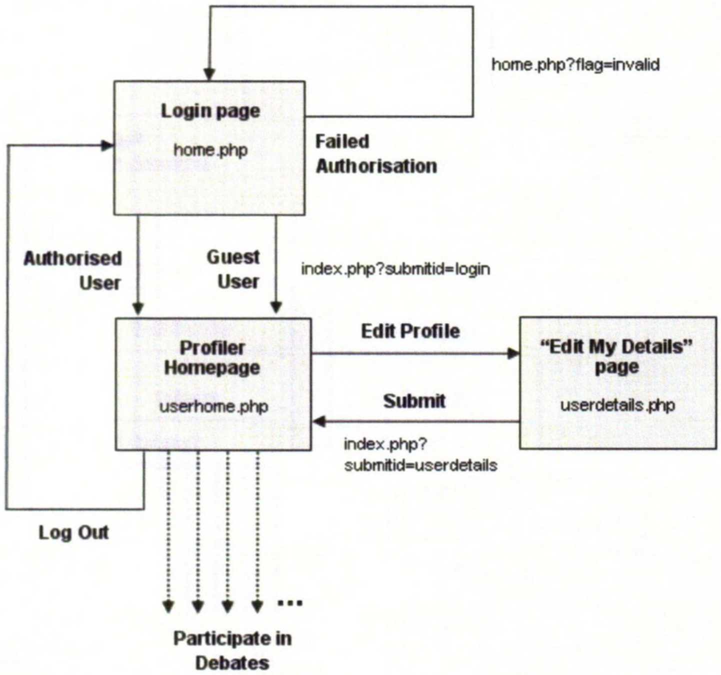


Figure B.5: Parmenides Website Design - Profiler System Storyboard

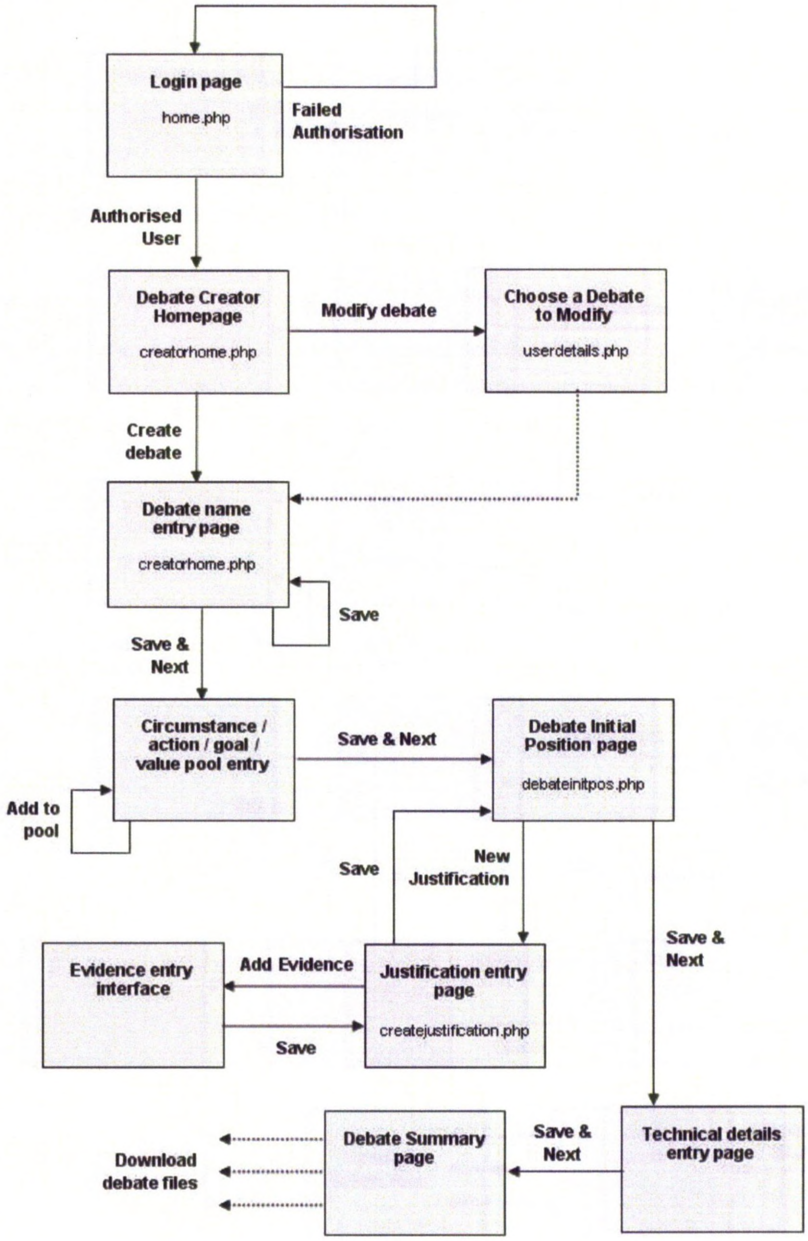


Figure B.6: Parmenides Website Design - Debate Creator Storyboard

B.4 Parmenides SQL Database

In this section, I provide design documentation for the Parmenides SQL database. The database forms an important part of the system, as it provides a repository through which data submitted can be stored for later analysis. Figure B.7 is an Entity-Relationship diagram presenting the main Parmenides database, to which user data submitted using debate webpages is written. The Parmenides Java application downloads data from this database in order to provide analysis of the data. Table B.15 provides extra information about the tables shown in this diagram.

Figure B.8 is an Entity-Relationship diagram which depicts the database which stores data related to the Parmenides debate creator. Tables B.16 and B.17 provides extra information about the tables shown in this diagram.

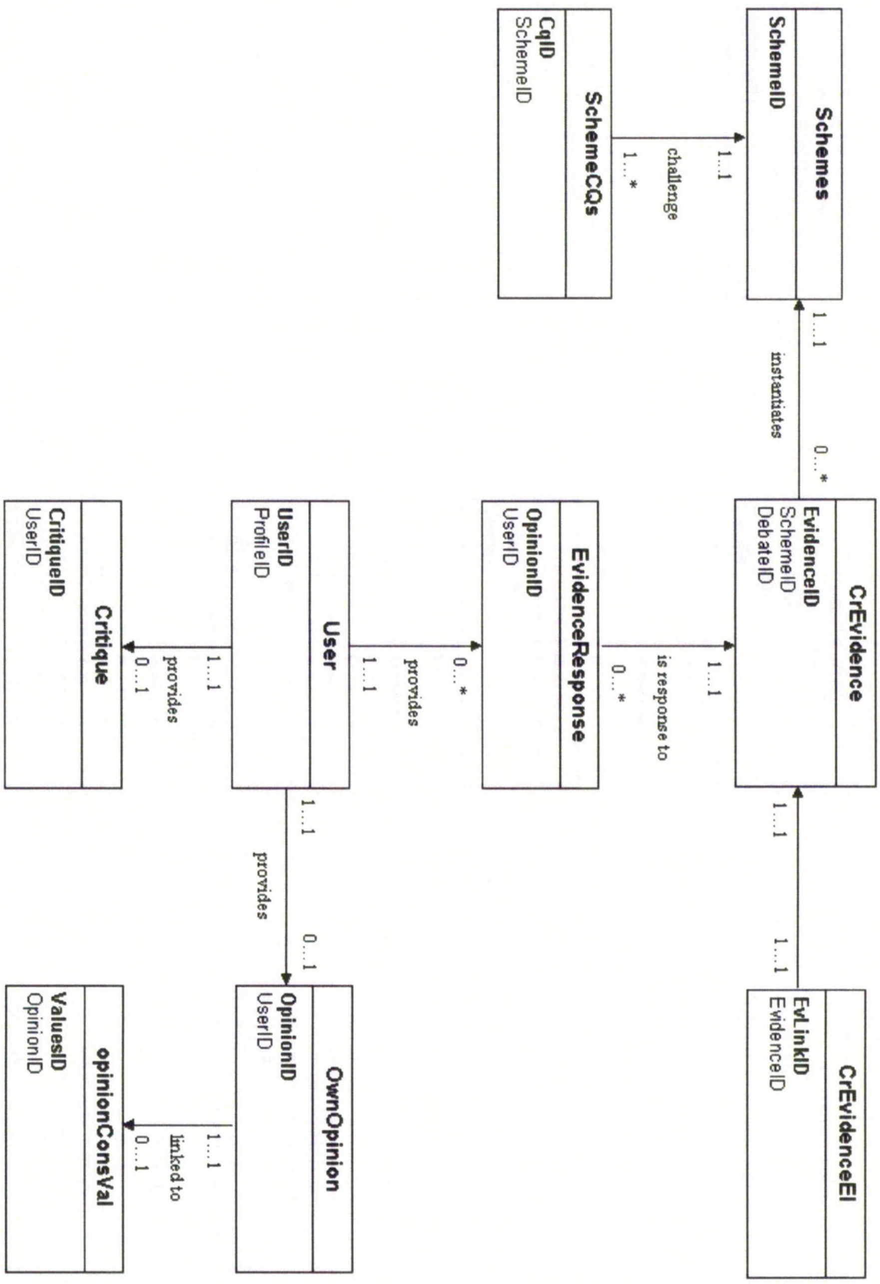


Figure B.7: Parmenides Database - ER Diagram

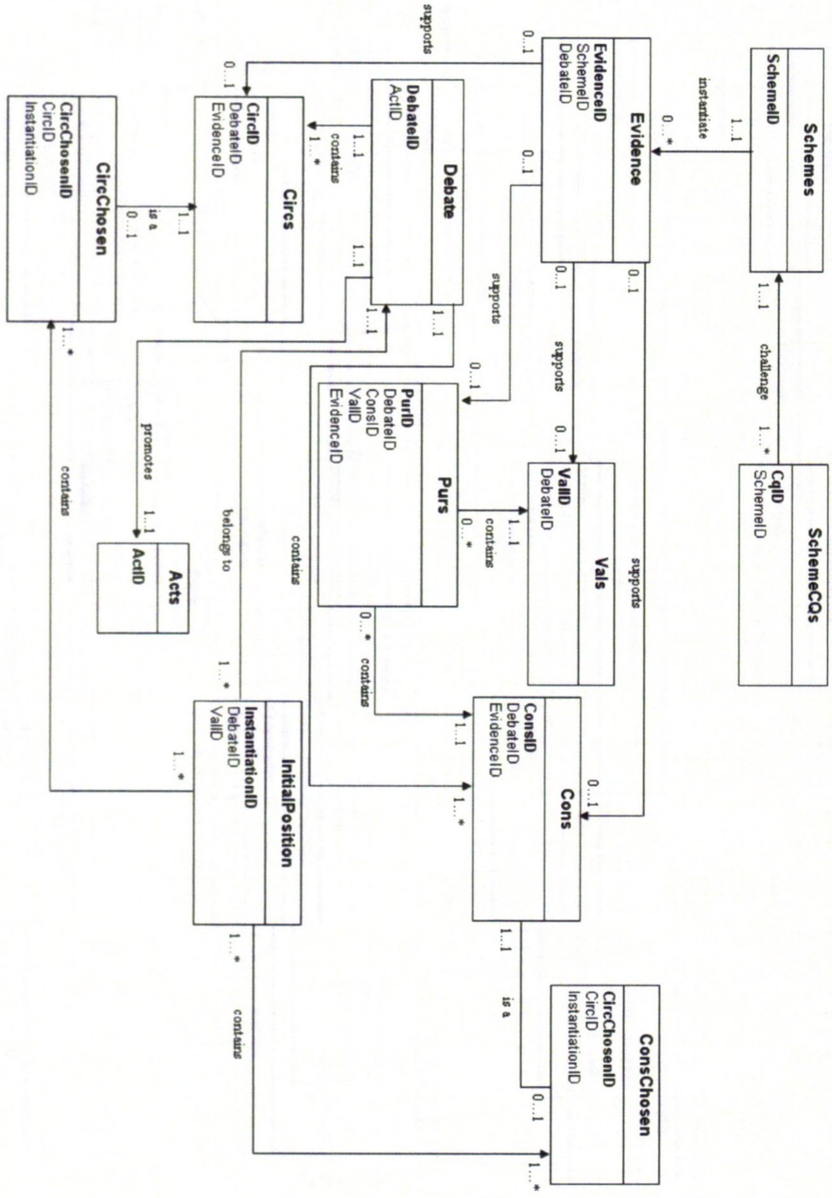


Figure B.8: Parmenides Debate Creator Database - ER Diagram

Entity Name	Description	Occurence
User	Stores information about the user's interaction with the system, for example the user's name, the time and date that the system was accessed, and whether they agreed with the initial position	One entry for each user that interacts with the Parmenides website
Critique	Stores the results of the user's critique of each element (i.e. whether they answered "Yes" or "No" to each circumstance, consequence, social value, etc.).	One entry for each user that submits a critique after entering their name
OwnOpinion	Stores the elements of the user's alternative position, if they decide to submit one	One entry for each users that decides to submit an alternative position after critiquing the initial position of the debate
opinionConsVal	Store the social values that users associate with each consequence statement that they choose in the alternative position section of the website. Each consequence may promote between 1 and 6 social values.	One entry for each consequence chosen by a particular user in the "Own Opinion" section of the Parmenides website
EvidenceResponse	Stores the response that a user gives to a particular piece of evidence that they are presented with. This table stores whether each Critical Question associated with the evidence was answered as "Yes" or "No"	One entry for each user's response to each critical question associated with a particular piece of evidence
CrEvidence	Contains the instantiation of the argumentation scheme for each piece of evidence. The data in this table is used to display the evidence to the user on the Parmenides website	One entry for each piece of evidence instantiated by the debate creator
CrEvidenceEl	Contains information that links each piece of evidence to the particular element of the initial position to which it belongs. The Parmenides website uses this table to determine whether a particular element has associated evidence.	One entry for each piece of evidence

Table B.15: Parmenides Database - Description of Entities

Entity Name	Description	Occurence
Debate	Stores basic information related to a debate, for example the title of the debate and the action promoted by it	One entry for every new debate created
InitialPosition	An initial position of the debate, which is an instantiation of the practical reasoning scheme	Each debate contains one or more initial position(s)
Circs	Each debate contains a pool of Circumstances that could be (but not necessarily are) relevant to the debate	Each debate contains a pool of one or more circumstance statement(s)
CircChosen	Circumstances that have been chosen in one or more initial positions of the debate. These are chosen from the pool of cirumstances.	Each initial position contains one or more circumstances, each circumstance belongs to one or more initial position(s)
Cons	Each debate contains a pool of Consequences that could (but not necessarily are) relevant to the debate	Each debate contains a pool of one or more consequence statement(s)
ConsChosen	Consequences that have been chosen in one or more initial positions of the debate. These are chosen from the pool of consequences	Each initial position contains one or more consequences, each consequence belongs to one or more initial position(s)
Vals	Social values that could be (but not necessarily are) relevant to the debate	Each debate contains a pool of one or more social values. Each initial position promotes exactly one social value.
Acts	Actions that could be (but not necessarily are) relevant to the debate	Each debate contains a pool of one or more actions. Each debate promotes exactly one action.

Table B.16: Parmenides Debate Creator Database - Description of Entities (1)

Entity Name	Description	Occurence
Purs	Purposes that are relevant to the debate. Purposes state that a particular Consequence promotes a particular Value	For each consequence added to a particular initial position, an entry in the "Purs" table is created.
Evidence	Instantiations of argument schemes, that can support any Circumstance, Consequence, Social Value, or Purpose	A circumstance, consequence, social value, or purpose can be supported by one piece of evidence. One piece of evidence supports either a circumstance, consequence, social value, or purpose.
Schemes	Generic versions of argument schemes, which can be instantiated as evidence	Each piece of evidence is an instantiation of exactly one argument scheme
SchemeCQs	Generic version of Critical Questions, that challenge various parts of the Argumentation Scheme	Each Critical Question is associated with one scheme, and each scheme can have one or more CQ(s).

Table B.17: Parmenides Debate Creator Database - Description of Entities (2)

Appendix C

Argumentation Schemes

In this appendix, I provide a full account of the argumentation schemes used throughout my thesis. The argument posed by the scheme is stated, along with the specific critical questions associated with each of the schemes.

C.1 AS1: Atkinson's Practical Reasoning Scheme

In the circumstances R, we should perform action A, to achieve new circumstances S, which will realise some goal G, which will promote some value V.

CQ1: Are the believed circumstances true?
CQ2: Assuming the circumstances, does the action have the stated consequences?
CQ3: Assuming the circumstances and that the action has the stated consequences, will the action bring about the desired goal?
CQ4: Does the goal realise the value stated?
CQ5: Are there alternative ways of realising the same consequences?
CQ6: Are there alternative ways of realising the same goal?
CQ7: Are there alternative ways of promoting the same value?
CQ8: Does doing the action have a side effect which demotes the value?
CQ9: Does doing the action have a side effect which demotes some other value?
CQ10: Does doing the action promote some other value?
CQ11: Does doing the action preclude some other action which would promote some other value?
CQ12: Are the circumstances as described possible?
CQ13: Is the action possible?
CQ14: Are the consequences as described possible?

CQ15: Can the desired goal be realised?
CQ16: Is the value indeed a legitimate value?

C.2 AS2: Argument from Position to Know

a is in a position to know whether *A* is true (false). *a* asserts that *A* is true (false). Therefore *A* is true (false).

CQ1: Is *a* in a position to know whether *A* is true (false)?
CQ2: Is *a* an honest (trustworthy, reliable) source?
CQ3: Did *a* assert that *A* is true (false)?

C.3 AS3: Argument from Expert Opinion

Expert *E* is an expert in Domain *D*. *E* asserts that Fact *A* is known to be true. *A* is within *D*. Therefore, *A* may (plausibly) be taken to be true.

CQ1: How credible is *E* as an expert source?
CQ2: Is *E* a genuine expert in *D*?
CQ3: Does *E*'s testimony imply *A*?
CQ4: Is *E* reliable?
CQ5: Is *A* consistent with the statements of other experts?
CQ6: Is *A* supported by evidence?

C.4 AS4: Argument from Commitment

a is committed to proposition *A* (generally, or in virtue of what she said in the past). Therefore, in this case *a* should support *A*.

CQ1: Is *a* really committed to *A*, and if so, is there evidence to support the claim that she is committed?
CQ2: If the evidence for the commitment is weak, could there be contrary evidence, or at least room for the rebuttal that this case is an exception?
CQ3: Is *A*, cited in the premise, the same as *A*, cited in the conclusion? If not, is there a direct relation between these two?

C.5 AS5: Argument from Popularity

If a large majority accept A as true, then there exists a (defeasible) presumption in favour of A. A large majority accept A as true. Therefore, there exists a presumption in favour of A.

CQ1: Can/should the truth of A be decided by a majority vote?
CQ2: Does the majority consist of a fair and representative collection of the overall population?
CQ3: Is the source of the statistic ("large majority") fair and unbiased?

C.6 AS6: Practical Reasoning About Competing Actions

Carrying out B in circumstances C promotes value b. Carrying out A in C precludes carrying out B for reason R. Value b is more desirable than any (all) values promoted by carrying out A. Therefore, we should carry out B instead of A.

CQ1: Does B really promote b?
CQ2: Is reason R a valid reason?
CQ3: Is b really more desirable than any (all) values promoted by carrying out A?
CQ4: Does carrying out A really preclude carrying out B?
CQ5: Are there any alternative actions to A that do not preclude B?

C.7 AS7: Argument from Consequences Based on Statistics

In circumstances C, according to source S, feature X was m. After carrying out action A, according to source S, feature X was n. m is not equal to n. Therefore it can be assumed that carrying out A affects feature X.

CQ1: Is source S reliable?
CQ2: Is source S unbiased?
CQ3: Is action A possible?
CQ4: Is A the only action that would lead to a statistic equally as good as, or better than, n?
CQ5: Is A the only action that could have lead to the change in feature X?
CQ6: Are there other reasons that this particular case can not be generalised?

C.8 AS8: Argument from Correlation to Cause

There is a positive correlation between A and B. Therefore A causes B.

CQ1: Is there a positive correlation between A and B?
CQ2: Are there a significant number of instances of the correlation between A and B?
CQ3: Is there good evidence that the causal relationship goes from A to B, and not just B to A?
CQ4: Can it be ruled out that the correlation between A and B is accounted for by some third factor (a common cause) that causes both A and B?
CQ5: If there are intervening variables, can it be shown that the causal relationship between A and B is direct (not mediated through other causes)?
CQ6: If the correlation fails to hold outside a certain range of causes, then can the limits of this range be clearly indicated?
CQ7: Can it be shown that the increase or change in B is not solely due to the way B is defined, the way entities are classified as belonging to the class of Bs, or changing standards, over time, of the way Bs are defined or classified?

C.9 AS9: The Causal Slippery Slope Argument

A_0 is up for consideration as a proposal that seems initially like something that should be bought about. According to source S: Bringing up A_0 would plausibly cause A_1, which would plausibly in turn cause A_2, and so forth. This would eventually cause a disastrous outcome B. Therefore, A_0 should not be brought about.

CQ1: Does the proponent's description of the initial action A_0 rightly express the proposal being advocated by the respondent?
CQ2: Are all of the causal links in the sequence supported by solid evidence to back it

up as a causal claim?
CQ3: Does this outcome plausibly follow from the sequence, and is it as bad as the proponent suggests?
CQ4: Is source S reliable?

C.10 AS10: Argument from Verbal Classification

a has a particular property F. For all x, if x has property F, then x can be classified as having property G. Therefore, a has property G.

CQ1: Does a definitely have F?
CQ2: Can the verbal classification (in the second premise) be said to hold strongly?

C.11 AS11: Argument from Cause to Effect

Generally, if A occurs then B will (or might) occur. In this case, A occurs (or might occur). Therefore, in this case, B will occur (or might occur)

CQ1: Is the casual generalisation strong (if it is true at all)?
CQ2: Is the evidence cited (if there is any) strong enough to warrant the generalisation as stated?
CQ3: Are there other factors that would or will interfere with or counteract the production of the effect in this case?

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